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APIOS-HAWKEYE LAKE BIOGEOCHEMISTRY STUDY DATA REPORT MARCH 1986 TO JUNE 1989

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APIOS - HAWKEYE LAKE BIOGEOCHEMISTRY STUDY

DATA REPORT - MARCH 1986 TO JUNE 1989

Report prepared by:

B.D. LaZerte, J. Findeis and L. Scott
Water Resources Branch
Ontario Ministry of the Environment

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PREFACE

The Data Report series is intended as a readily available source of basic data collected for lakes and watersheds in Ontario. These data were collected as part of the Acid Precipitation in Ontario Study.

The Acid Precipitation in Ontario Study (1979 - present) was initiated, in part, to investigate the effects of the deposition of strong acids on aquatic and terrestrial ecosystems in Ontario. The primary findings of these studies have been, and will continue to be, published as reviewed papers and technical reports.

ABSTRACT

The Hawkeye Lake part of the APIOS Biogeochemistry study was redesigned in 1986 to be compatible with existing programmes at the Dorset Resarch Centre and to provide a low acidic deposition control site. Sampling was continued until June 1989. During this period, wet deposition of trace metals and acidic substances was substantially less than observed at Dorset. The annual precipitation depth was ony 489 and 713 for 1987 and 1988 respectively, below the regional average of 750. As a result, the water table dropped during the study and we had substantial difficulties in collecting any soil water samples. Sampled soil water was relatively high in pH (5-7), compared to Dorset samples collected at the same horizons. The base cation content of these soils is sufficient to neutralize even the organic acidity of the LFH. The pH of various surface water samples was considerably lower, especially at sites heavily influenced by wetlands. Apparently, the water draining the wetlands has had little contact with mineral soils with a high base cation content. The pH at the weir (HK01) dropped steadily from 1984, perhaps because of the lowering of the water table. Most aluminum at Hawkeye Lake is bound to DOC.

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1.0 INTRODUCTION

The Dorset Research Centre of the Ontario Ministry of the Environment began supervision of the APIOS Biogeochemistry Programme in March 1986. At this time, all projects in the Biogeochemistry programme were re-evaluated; some were dropped, others were substantially modified.

The Hawkeye Lake part of the Biogeochemistry Programme was modified to make the programme compatible with the goals and other programmes of the Dorset Research Centre. A contract was given to Senes Consultants Ltd. to prepare a series of reports documenting the older methods and results of the Hawkeye Lake project up to March 1986. These reports are available for perusal at the Dorset Research Centre and at the Thunder Bay Regional Office of the Ontario Ministry of the Environment. They include:

- APIOS: Hawkeye Lake - Field procedures manual.
- APIOS: Hawkeye Lake - Stream water, ground water, snowpack and lake studies.
- APIOS: Hawkeye Lake - Incident precipitation and deposition studies.
- APIOS: Hawkeye Lake - Litterfall studies.
- APIOS: Hawkeye Lake - Grove throughfall and stemflow studies.
- APIOS: Hawkeye Lake - Litter decomposition studies.
- APIOS: Hawkeye Lake - Forest inventory and biomass/bioelement studies.
- APIOS: Hawkeye Lake - Soil classification and nutrient/element studies.

The litterfall, grove throughfall and stemflow, forest inventory and biomass/bioelement, soil classification and nutrient/element, and lake studies were all discontinued as of March 1986. The remaining on-site litter and twig decomposition bags were collected as per the original schedule; however, the samples were put into storage and not analyzed. The remaining stream, ground water, snowpack, incident precipitation and deposition studies were all modified extensively. In addition, a new soil water study using lysimeters was implemented. The study continued in this fashion up to June 1989 when it was terminated.

The Hawkeye Lake snowpack studies (including chemical analyses) have already been published with other Biogeochemistry snowpack data from the Plastic and Harp Lake sites (Findeis et al., 1989). All other aspects of the post March 1986 Hawkeye Lake study will be documented here. All tables and figures presented in this document are available in LOTUS format files on IBM PC compatible diskettes from Bruce LaZerte, Dorset Research Centre.

2.0 SITE

The Hawkeye Lake study site is located about 60 km north of Thunder Bay, Ontario (Figure 1). A detailed description and map of the Hawkeye Lake site can be found in Section 2.2 of the Field Procedures Manual prepared by Senes. Appendix A lists the new Sample Information System (SIS) Station ID codes and station abbreviations (STN) used

since March 1986 for the Hawkeye Lake study. Appendix B lists the UTM coordinates for the stations.

3.0 METHODS

Appendix C gives detailed field methods for the collection of water samples and their field quality assurance at the Hawkeye Lake study for the period starting March 1986.

3.1 Chemical Analyses and Quality Assurance

When small sample volumes were collected, it was necessary to measure the pH in the Hawkeye Lake laboratory trailer, not at the Thunder Bay laboratory as usual. Frequent quality control analyses, however, kept the two workstations reasonably comparable.

All dissolved inorganic carbon (DIC) analyses had to be discarded because of long delays between collection and analysis at the Rexdale laboratory (see Special Studies section below). It was unfortunate that the DIC analyses could not be performed at Thunder Bay.

When DIC is not available, it is possible to estimate bicarbonate concentrations from alkalinity analyses (ALKTI) in waters with low DOC (dissolved organic carbon). Unfortunately, most Hawkeye samples had significant quantities of weak organic acids

(DOC) which were titrated in the Gran alkalinity titration along with the bicarbonate. Consequently, it was impossible to estimate bicarbonate accurately.

Seasonal trends in all chemical parameters were examined for each station. Outliers at a station were deleted when all of the below were true:

i) they were not duplicated at a similar station

ii) they were not duplicated in the same season of another year

iii) there was no known geochemical explanation

Unfortunately, a charge balance criterion was not usually helpful because the poor bicarbonate estimates based on alkalinity usually gave poor charge balances (see above). Additional criteria were the comparison of calculated conductivity and alkalinity against with actual analyses.

Once a month, four replicate samples from the stream stations: Weir A2, EF12, J21-22 and Q10 were collected to estimate analytical and sampling precision combined.

Detailed methods for the quality assurance of precipitation bag liners is provided in Appendix C.

Quality assurance for trace metal collection in precipitation was the same as LaZerte et al. (1989).

3.2 Precipitation, Meteorology and Ground Frost

After March 1986, the Hawkeye Lake precipitation site was modified to be identical to those sites maintained at the Dorset Research Centre (de Grosbois et al., 1990). In addition, wet/only collection on an event basis using polyethylene bags in the existing Aerochemetrics collector was inaugurated.

Late in 1988, another wet/only collector was installed for the collection of trace-metals in precipitation. Its operation and the analysis procedures were identical to those used at the Dorset Research Centre (LaZerte et al. 1989).

From March 1986 to November 1988, a Campbell Scientific model 201 temperature/relative humidity probe, connected to a CR-21 Micrologger was used to determine maximum, minimum and mean daily temperatures and to determine maximum, minimum and average daily relative humidity from hourly readings. After November 1988, a Campbell Scientific model 207-C temperature/relative humidity probe connected to a 21X Micrologger was used.

A Belfort model 5915 Cumulative Rainfall Transmitter connected to the Campbell Scientific Micrologger was used to record precipitation. Daily precipitation values (water equivalence during snowfall events) were calculated from the hourly recordings. In addition, precipitation event volumes were obtained from the bulk and routine wet/only precipitation collectors.

The estimation of depth of ground frost is documented in Appendix D. Snow pack depth was also recorded along with ground frost independently of the main snow pack study (Findeis et al., 1989).

3.3 Lysimeters and Tensiometers

In the summer of 1987, tension and zero-tension lysimeters were placed in the five study groves at Hawkeye Lake. Separate well-drained pits for tension and zero-tension lysimeters were prepared. Soil horizons in each pit were classified by Dianne Corrigan of the OME Air Resources Branch. The tension lysimeters were 15 cm alundum plates from Pacific Lysimeters of Seattle, Washington prepared as described in Neary and Tomassini (1985). The zero tension lysimeters were 45x18 cm plexiglass troughs. Duplicate lysimeters were installed 35-40 cm into the face of each pit immediately under the chosen horizon, avoiding roots and large rocks. An insulated, covered, plywood box was then constructed in the pit to contain the bottles, vacuum apparatus and propane heater. The two lysimeters in each horizon were tied together in the pit box for sample collection. Classifications, depths and station codes for the lysimeters are in Appendix A. Appendix C gives more details as to the field operation of the lysimeters for collecting water samples.

Tensiometers were installed and monitored as outlined in Appendix E.

3.4 Weir and Stream MultiStations

Stream gauging at the HK01 weir and related hydrological procedures were performed as specified in Locke and Scott (1986). See section 2.4 of the field procedures manual prepared by Senes for construction details of the weir. Gauging frequency was weekly during normal flow periods and daily during the spring and fall freshet. The stage-discharge graph (Figure 2) was used to calculate daily discharge from continuous stage records when available (Locke and Scott, 1986). Missing daily discharge was estimated by drawing a straight line between two nearest dates.

3.5 StandPipes

As well as sample collection for chemical analysis, depth to groundwater was manually recorded at each visit to a standpipe. One station (H-7) had an A71 Leopold and Stevens water level recorder in a heated (after Fall 1986) enclosure continuously recording groundwater levels.

3.6 Special Studies

In the spring of 1988, Peter Wilson and the Mobile Laboratory of OME's Laboratory Services Branch analyzed both aluminum species (LaZerte et al. 1988) and DIC at Hawkeye Lake, immediately after the samples were collected, using the same methods as the Dorset and Rexdale laboratories. Simultaneously collected samples were also sent to Rexdale

laboratory (DIC) and Dorset (aluminum speciation). The intent of the study was to examine the effects of an average 2 week transport/storage time to Rexdale/Dorset on DIC analyses and to provide some information about aluminum speciation at Hawkeye Lake as it was not routinely performed.

4.0 RESULTS AND DISCUSSION

4.1 Chemical Analyses and Quality Assurance

With one exception, Hawkeye Lake laboratory pHs agreed well with the Thunder Bay laboratory pHs (Table 1).

The mean and percent coefficient of variation [(standard deviation/ mean)*100] was calculated for each set of four replicate samples collected. Then the grand mean and the mean coefficient of variation for each parameter at each site was calculated and is presented in Table 2. In general, the field precision is acceptable. Large coefficients of variation are usually where the mean field concentration is low (e.g. Mn and Alk).

The field procedures and bags used for both wet-only and bulk precipitation contributed negligible contamination as demonstrated by the monthly field bag checks (Table 3).

4.2 Precipitation, Meteorology and Ground Frost

For Hawkeye wet-only trace metal collections, copper values were not significantly different from the field blanks (Table 4). All other metals were significantly elevated at the $p=0.05$ level (Kruskal-Wallis), with median (mean) blank subtracted values of 0.67 (0.73), 1.49 (0.99) and 0.03 (0.03) $\mu g/L$ for Pb, Zn and Cd respectively. These values are roughly one third those reported for the Muskoka-Haliburton region of Ontario (LaZerte et al. 1989).

Cumulative precipitation depth between collections and precipitation chemistry for the Hawkeye wet-only (HKP1) and bulk collector (HKP2) are presented in Figures 3-4 respectively.

Daily precipitation depth (Belfort gauge), maximum/minimum temperature and minimum relative humidity are presented in Figures 5a-c. The maximum daily relative humidity was commonly an artefact (100%) determined by early morning condensation on the probe and thus, only minimum daily relative humidities are reported.

The cumulative annual precipitation depth as measured by the Belfort gauge was 489mm and 713mm for 1987 and 1988 respectively. These numbers are below the regional average (~750mm) and, coupled with groundwater records (Figure 9), indicate that water storage at the site was becoming significantly depleted during the period of investigation.

Frost penetration and snow depth for four sites (Po, Bw, Fb, Pw) are presented in Figures 6a-d. At all sites, the frost penetrated substantially deeper in 1987-88 than in 1988-89 because of the relatively light snow cover in January and February 1988.

4.3 Lysimeters and Tensiometers

Because of the drought conditions, the tensiometers did not operate properly throughout this period. The fluid within the tensiometer drained out before any stable reading could be obtained.

For the same reason, few lysimeter water samples were collected, mostly zero-tension during and immediately after precipitation events. It is possible that macropore flow provided water to the zero-tension lysimeters, but that the events were not of sufficient duration to significantly affect the water content of the soil matrix. Hence, tension lysimeter collections were rare. Table 5 presents what few zero-tension results are available.

The pHs of these samples are high (5-7) relative to soil water samples collected in the Muskoka-Haliburton area. This is true even in the LFH layer where high organic acid levels and low sulphate levels are common. The base cation content of these soils is apparently sufficient to neutralize the natural organic acidity in the LFH layers.

Although at HKZ01, most DOC is stripped from the soil water by the time it reaches the upper A and B mineral horizons, the high DOC levels in HKZ03 A, B1, B2 and HKZ04

A, B1, B2 horizons suggest that these waters have not had intimate contact with the soil matrix, perhaps because of macropore flow.

4.4 MultiStations

Multistation chemistry is presented in Figures 7a-d. A graph of stream discharge at the weir (A-2) is placed in the first panel of Figure 7a for reference.

The pH in these streams is related to DOC, with the high DOC streams (e.g. HK06, HK08, HK09, HK10) having pHs that occasionally drop below 5. The DOC at these sites is probably derived from the upstream wetlands. Apparently, the water draining these wetlands has had little contact with mineral soils as base cations have not completely replaced the organic acidity (as has happened in the upland soil water solutions). The pH at HK01 dropped steadily from 1984, perhaps because of the lowering of the water table which would cause the oxidation of reduced substances and perhaps release more organic acids.

4.5 StandPipes

Standpipe chemistry and depth to groundwater is presented in Figures 8a-d. The first panel of Figure 8a is the groundwater elevation at well HKW07. The elevation of each standpipe is given in appendix B. Figure 9 provides a comparison of continuous groundwater levels at well HKW07 with discharge at weir HKA2.

With the exception of HKW16, groundwater pH is usually high (6 or greater) as are base cation levels. HKW16 was probably anoxic, as it had extremely high ammonia and low sulfate levels. Oxidation of reduced substances after sampling of this well would cause the low pH.

Some of the groundwater wells had high levels of DOC as well. Much of this DOC is probably derived from the wetlands, although macropore flow from the LFH layer of the soils cannot be excluded.

4.6 Special Studies

Peter Wilson's Mobile Laboratory intercomparison study demonstrated that, on average, 40% of sample DIC was lost during transport and storage from Hawkeye Lake to Rexdale.

Although aluminum levels were high in the LFH soil layer, or in wetland outflows, most of the aluminum was organic at Hawkeye Lake (Al_tot = 3 + 1.25 Al_org [$\mu g/L$], R_2 = 0.97). This has also been found in the Muskoka-Haliburton area of Ontario and elsewhere (LaZerte 1989). In the acidified catchments of Muskoka-Haliburton, there are also large amounts of inorganic aluminum released from the mineral layers of soil. However, because of the relatively high pHs in the mineral layer of the Hawkeye Lake soils, little inorganic monomeric aluminum was found there or elsewhere in the catchment.

More details of the comparison can be found in Wilson (1988).

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APPENDIX A: Station Identification Numbers

	Map Coord	Stn	SIS Station ID	
Multi Station Streams				
	A/2	HK01	990103 001 02*	
	BC/6	HK02	990103 002 02	
	EF/12	HK03	990103 003 02*	
	E/14	HK04	990103 004 02	
	F/14	HK05	990103 005 02	
	J/21-22	HK06	990103 006 02*	
	T/13	HK07	990103 007 02	*Stream
	P/12	HK08	990103 008 02	replicates
	Q/10	HK09	990103 009 02*	station
	L/6-7	HK10	990103 010 02	
	I/6	HK11	990103 011 02	
	C/2	HK12	990103 012 02	
	U/14	HK13	990103 013 02	
Standpipes:				
		HKW02	990103 002 06	
		HKW03	990103 003 06	
		HKW04	990103 004 06	
		HKW05	990103 005 06	
		HKW06	990103 006 06	
		HKW07	990103 007 06	
		HKW09	990103 009 06	
		HKW10	990103 010 06	
		HKW12	990103 012 06	
		HKW14	990103 014 06	
		HKW15	990103 015 06	
		HKW16	990103 016 06	
		HKW17	990103 017 06	
		HKW18	990103 018 06	
		HKW20	990103 020 06	
		HKW21	990103 021 06	
		HKW23	990103 023 06	
		HKW24	990103 024 06	

Lysimeters:

			Horizon	Depths
Poplar Tension:				
	HKT01L	990103 111 04	LFH	6,7 cm
	HKT01A	990103 112 04	Ae	9,10 cm
	HKT01B1	990103 113 04	Bhf	30,32 cm
	HKT01B2	990103 114 04	Bf	43,43 cm
	HKT01BC	990103 115 04	Bm	60,61 cm
Poplar Zero Tension:				
	HKZ01L	990103 121 04	LFH	5,5 cm
	HKZ01A	990103 122 04	Ae	16,16 cm
	HKZ01B1	990103 123 04	Bhf1	35,40 cm
	HKZ01B2	990103 124 04	Bhf2	47,50 cm
	HKZ01BC	990103 125 04	Bm	65,65 cm
Balsam Fir Tension:				
	HKT02L	990103 211 04	LFH	3,4 cm
	HKT02A	990103 212 04	Ae	
	HKT02B1	990103 213 04	Bhf1	30,30 cm
	HKT02B2	990103 214 04	Bhf2	51,51 cm
	HKT02BC	990103 215 04	C	65,67 cm
Balsam Fir Zero Tension:				
	HKZ02L	990103 221 04	LFH	4,4 cm
	HKZ02A	990103 222 04	Ae	
	HKZ02B1	990103 223 04	Bhf1	25,26 cm
	HKZ02B2	990103 224 04	Bhf2	43,45 cm
	HKZ02BC	990103 225 04	BC	82,83 cm
White Pine Tension:				
	HKT03L	990103 411 04	LFH	7,7 cm
	HKT03A	990103 412 04	Ae	12,15 cm
	HKT03B1	990103 413 04	Bf1	35,42 cm
	HKT03B2	990103 414 04	Bf2	
	HKT03BC	990103 415 04	BC	
White Pine Zero Tension:				
	HKZ03L	990103 421 04	LFH	9,10 cm
	HKZ03A	990103 422 04	Ae	16,20 cm
	HKZ03B1	990103 423 04	Bf1	21 cm
	HKZ03B2	990103 424 04	Bf2	35,39 cm
	HKZ03BC	990103 425 04	BC	58 cm

			Horizon	Depths
White Birch Tension:				
	HKT04L	990103 611 04	LFH	4,5 cm
	HKT04A	990103 612 04	Ae	10,12 cm
	HKT04B1	990103 613 04	Bhf1	23,25 cm
	HKT04B2	990103 614 04	Bhf2	47,49 cm
	HKT04BC	990103 615 04	BC	72,78 cm
	HKT04C	990103 616 04	C	105,109 cm
White Birch Zero Tension:				
	HKZ04L	990103 621 04	LFH	11,12 cm
	HKZ04A	990103 622 04	Ae	17,19 cm
	HKZ04B1	990103 623 04	Bhf1	19 cm
	HKZ04B2	990103 624 04	Bhf2	57,60 cm
	HKZ04BC	990103 625 04	BC	60,60 cm
Black Spruce Zero Tension:				
	HKZ05L	990103 921 04	OF1	4,5 cm

Precipitation:			
	HKP1	990103 001 23	Wet/Only
Aerochemetric			
	HKP2	990103 002 23	Bulk
	HKP8	990103 008 23	Wet/Only Metals

Snow:			
	Balsam Fir	HKSFB	990103 003 23
	White Birch	HKSBW	990103 004 23
	Poplar	HKSPO	990103 005 23
	White Pine	HKSPW	990103 006 23
	Black Spruce	HKSSB	990103 007 23

APPENDIX B: U.T.M. Locations

		Easting	Northing
Precipitation Sites:		317480	5393150
Multi Stations:	HK01	317280	5393530
	HK02	317500	5393410
	HK03	317825	5393275
	HK04	317900	5393300
	HK05	317900	5393250
	HK06	318260	5393050
	HK07	317850	5392550
	HK08	317800	5392750
	HK09	317700	5392700
	HK10	317550	5392940
	HK11	317500	5393100
	HK12	317300	5393400
	HK13	317950	5392500
Standpipes:	HKW02	317550	5393000
	HKW03	317475	5392975
	HKW04	317600	5392850
	HKW05	317800	5392800
	HKW06	317900	5392785
	HKW07	318000	5392470
	HKW09	318050	5392750
	HKW10	318010	5392940
	HKW12	318260	5393070
	HKW14	317825	5393275
	HKW15	317975	5393375
	HKW16	318550	5393200
	HKW17	317710	5393150
	HKW18	317580	5393150
	HKW20	317525	5393350
	HKW21	317360	5393490
	HKW23	317220	5393450
	HKW24	317350	5393350
Lysimeter Pits:			
Poplar		317350	5393350
Balsam Fir		317475	5392900
White Pine		317990	5393400
White Birch		317990	5392600
Black Spruce		318550	5393200

APPENDIX C: **Field Methods for the Collection and Quality Assurance of Water Samples**

Water Distillation Quality Control

- Samples of distillate shall be checked for pH and conductivity on a weekly basis.
- Recorded values are to be submitted with the monthly summary report.
- Discrepancies of .2 units of pH, less than or greater than pH 5.5, and conductivity ranges that are $\geq$1.5, should be reported to the field supervisor immediately.

pH Probe Storage Procedures

- If the probe is not in use for a period $\geq$2 days, then it should be stored in pH 4 buffer solution.
- Before using the probe again wash, thoroughly with D.D.W. and let stand in pH 7 buffer solution for a period of 0.5 hours.
- Wash the probe once again with D.D.W. and calibrate using prescribed techniques (see manual with meter).
- If the probes are to be used daily, store in pH 7 buffer solution.

Filtration

Use Polyester PeCap mesh used on all field filtration apparatus:

- Open Streams: 80 μm during normal flow periods
  35 μm during extended periods of low flow
- Standpipes: 35 μm
- Precipitation: 80 μm at the throat of bulk collector
- Lysimeters: 80 μm (zero tension only)
- Snow Course: 80 μm

Field Filtration

- Filters are to be transported in a clean plastic bag.

- Filters are to be rinsed three (3) times before sampling, once upon completion and then returned to the plastic bag.

- Replacement mesh shall be transported in a polystyrene container.

- Contaminated mesh shall be stored in a polystyrene container marked with appropriate mesh size, and returned to the laboratory for cleaning.

Laboratory Filter Wash Procedures

- Prepare wash baths in containers with tightly sealing lids:
  - Two (2) nalgene containers 10 l filter bodies;
  - Sufficient polystyrene containers 485 ml for appropriate mesh sizes.

- Individual baths will be prepared using Acationex alkaline metals free detergent and a 5% solution of Baker Instra Analysed Nitric Acid.

- Pre-rinse filter bodies and mesh and D.D.W. to remove field debris.

- Soak filter bodies and mesh first in Acationex for 48 hours, rinse three (3) times with D.D.W.

- Place filter bodies and mesh in acid bath for a period of 48 hours.

- Filter bodies shall be rinsed inside and out three (3) times with D.D.W. and stored in clean plastic bag.

- Polyester mesh shall be rinsed three (3) times with D.D.W. and stored in appropriately marked polystyrene bottles.

Bulk Precipitation - Routine

Field

- Monitor the Belfort gauge for an increase in precipitation deposition of 2.5 mm since the last collection.

- As each collector collects over an area of 2,500 cm^2, approximately 5 mm deposition is required to obtain 1,150 ml of sample. With two collectors at each site, only 2.5 mm deposition is required to provide a bulked sample of 5 mm.

- Carry clean new bags to the site in a clean outer bag. Do not expose their inner surfaces to contamination; in order to prevent this, wear plastic gloves at all times.

- Inspect the funnel for contamination.

- Remove the large Nalgene container and bag from the collector. Secure the collection bag just above the water line with a plastic pull tie, fold over and tie again.

- Remove the replacement plastic bag from the outer bag and place the sample bag inside the outer bag securing the top with a tie.

- Place the clean bag inside the Nalgene container and open to shape of the container. For summer operation, replace lid on container, during winter leave top off.

- Remove the 80μm polyester mesh in the throat of the funnel and the tygon tubing on the outlet orifice, summer operation only.

- Clean the bulk collector surface if necessary as specified in the methods manual DR 86/4. Replace the mesh filter and tygon tubing each time the collection vessel is changed.

- Field observations which might affect quality of sample should be noted in field book.

<u>Laboratory Preparation</u>

- Set up filtration apparatus on Burett stand using 80 μm mesh.

- Weigh the bag and obtain the sample volume by subtracting an average bag weight.

- Pre-rinse all bottles three (3) times with D.D.W.

- Wash one corner of the bag with D.D.W. and snip it off.

- Rinse each bottle once with actual sample (50 ml minimum), then fill.

- Refrigerate all samples until submission at least weekly. Thunder Bay laboratory samples should be submitted as soon as possible after collection.

- Note: Plastic gloves are to be worn at all times during the above procedures.

Wet Only Precipitation - Routine

Field

- As each collector collects over an area of 638 cm^2, about 15.7 mm deposition is required to obtain 900 ml of sample.
- Inspect the collector at least weekly, replacing the bag at each inspection.
- Carry clean new bags to the site in a clean outer bag. Do not expose the inner surfaces to contamination. In order to prevent this, wear plastic gloves at all times.
- If there is any sample volume, secure the bag just above the water line with a plastic pull tie, fold over and tie again, then place inside the clean outer bag used to transport the replacement bag.
- Place the clean bag inside the plastic container and secure around outer edge with a nylon cord.
- Note: Field observations other than routine condition codes affecting quality of sample should be noted in field book (e.g. collector open during non-event period).

Laboratory Preparation

- Weigh the sample, if less than 1,000 ml is available including any previous sample, store the bag in a clean protective container in the refrigerator until the next collection.
- If there is sufficient sample in the bag plus any previous sample, pool all the bags into one and mix thoroughly by shaking.
- Pre-rinse alkalinity bottles three (3) times with D.D.W.
- Wash one corner of the bag with D.D.W. and snip it off.
- Rinse each bottle once with actual sample (50 ml minimum) then fill.
- Refrigerate all samples until submission at least weekly. Thunder Bay laboratory samples should be submitted as soon as possible.
- Refrigerate all samples until submission at least weekly. Thunder Bay laboratory samples should be submitted as soon as possible.
- Note: Do not filter these samples.

Wet Only Precipitation - Metals

- As each collector collects over an area of 638 cm^2, about 3.5 mm deposition is required to obtain 200 ml of sample.

- Inspect the collector weekly; do not replace the bag until the minimum 3.5 mm of sample is present.

- Carry clean new bags to the site in a clean outer bag. Do not expose the inner surface to contamination. In order to prevent this, wear plastic gloves at all times.

- If there is enough sample volume, secure the bag just above the water line with a plastic pull tie, fold over and tie again, then place inside the clean outer bag used to transport replacement bag.

- Place the clean bag inside the plastic container and secure around outer edge with a nylon cord.

Laboratory Preparation - Metals Only

- Weigh the sample, subtracting bag and nylon pull ties. Record all field related data on sample submission sheets.

- Ship to Dorset via Purolator for analysis.

Precipitation Quality Control

Bulk - Routine

- Once a month, take two (2) bags transported in clean outer bags to the precipitation site.

- Remove the old bags as normal in each of the two collectors and install the new clean bags.

- Immediately replace the just installed bags, tie and return them to the lab inside clean transportation bags.

Laboratory Procedures

- In the laboratory, add 2,500 ml of best quality D.D.W. to each bag.

- Tie shut, double bag and allow to stand in a clean area for two days, and submit under normal precipitation parameter codes.

- Simultaneously submit two (2) samples of the same D.D.W. used in the bag wash, under normal precipitation parameter codes.

Wet Only - Routine

- Once a month take one (1) bag, transported in a clean outer bag to the precipitation site.
- Replace the old bag as normal and install the new clean bag.
- Close the top of the wet only collector.
- Immediately replace the just installed bag, tie and return to the laboratory in the clean transportation bag.

Laboratory Procedures

- In the laboratory, add 1,250 ml of best quality D.D.W. to the bag.
- Double bag, tie shut and allow to stand in a clean area for 48 hours.
- Submit using HPBC sample parameters and HPWT sample parameters.
- Simultaneously submit two (2) samples of the same D.D.W. used for the bag wash, using normal precipitation sample codes.
- Note: If bulk precipitation and wet only quality control are done at the same time and put on the same submission, only two (2) D.D.W. blanks need to be submitted.

Wet Only - Metals

- Twice a month, take one (1) bag, transported in a clean outer bag to the precipitation site.
- Replace the used bag as normal and install the new clean bag.
- Close the top of the wet only collector.
- Immediately replace the just installed bag, tie and return to the laboratory in the clean transportation bag.
- Submit the bag to Dorset for analysis.

Stream and Standpipe Collections

- Bottles shall be washed three (3) times (minimum 50 ml) using the field filter. Plastic gloves are to be used at all times while sampling.

- Acidify the yellow cap (FEUT, MNUT, ALUT) with 0.25 ml or five drops of Aristar Nitric Acid in the fume hood, using standard safety procedures DRC/85. Mark the bottle with HNO_3 after acidifying.

- Refrigerate all samples until submission. Submit samples at least weekly, with the Thunder Bay sample parameters submitted as soon as possible.

- Note: A field pH is required whenever there is insufficient volume to rinse and fill the brown alkalinity bottle.

Stream Quality Control

- Once a month, submit four (4) samples from Weir A2, EF12, J21-22 and Q10.

- Samples are to be taken simultaneously and submitted under normal test groups to Thunder Bay and Central laboratories.

- Collect four (4) additional pH vials when sampling these sites and process them for field laboratory pH.

- Standard deviation of these replicates and the annual average standard deviations are to be reported for each parameter analyzed.

- The vial pH should be compared with Thunder Bay laboratory pH and discrepancies immediately reported.

Lysimeters

Tension Field Procedures

- Site specific bottles are taken to the field with appropriate bag liners inserted (5 lb plastic food quality bags).

- Record date, time of arrival, cylinder pressure, manifold pressure and conditions affecting sample integrity.

- Upon arrival, remove the vessel (trapping the bag to the outside of the throat) and cap with the lid from the replacement vessel.

. Replace the bottle with one specific to that horizon, ensuring that the plastic bag liner is totally inside the bottle.

. Vacuum cylinder will be evacuated to a minimum of 24-27 inches of mercury.

. Manifold gauge shall be zeroed before attaching vacuum source. This is accomplished by removing a line from the secondary side of the manifold.

. Then, attach the source of vacuum and apply a pressure of 38 inches of water to the manifold gauge.

. Close stop cocks to plate.

. Open valves individually at manifold and apply vacuum to the collection vessel. The following results should occur:
  - Evacuation from the source cylinder should be noted;
  - Manifold gauge should drop rapidly and then return stabilizing at 38 inches of water;
  - If these observations are not noted, then check vacuum system lines for obstructions, or an open stop cock.

. Apply vacuum to individual plates within each horizon by adjusting the three-way stop cock.

. Isolate vacuum source (cylinder) and check for the following:
  - Leaks in the primary system:
    · vacuum cylinder and connectors;
    · manifold assembly.
  - Leaks in the secondary system:
    . lines from manifold;
    . stop cock;
    . connectors;
    . vacuum shields (water trap);
    . bottle caps (i.e. throat and connectors).
  - A decrease at the vacuum source gauge. (If no drop is apparent then a perfect seal exists between the plate and soil horizon.)
  - If a rate of decrease is greater than 5 inches of mercury in 10 seconds, then isolate this plate.

. Repeat this procedure at each plate and note the rate of drop in the field book.

. Upon completion of individual plate testing, a minimum storage vacuum of 20-22 inches of mercury should be available. At this time, activate all positive tested plates. If a drop of 10 units in 10 seconds is noted at all plates, then isolate plates with rate of least decrease.

Laboratory Procedures

- Weigh the sample subtracting bag/bottle.
- If sufficient sample (725 ml) is available, do all parameters. With insufficient sample, use priority list.
- Rinse bottle, insert plastic bag and inflate.
- Note: Tension leachate samples are not to be filtered.

Zero Tension Field Procedures

- Site specific bottles are taken to the field with appropriate bag liners inserted (8 lb and 12 lb plastic food quality bags).
- Record site specific data: time of arrival, date, and conditions affecting sample integrity.
- Cap the sample with the lid from the replacement vessel.
- Replace the bottle with one specific to that horizon, ensuring that the plastic bag liner is folded over the outside of the throat.

Laboratory Procedures

- Weigh the sample subtracting bag/bottle.
- If sufficient sample is available (725 ml), do all parameters. With insufficient sample, use priority list.
- Rinse bottle, insert plastic bag and inflate.
- Note: Zero tension leachate samples are to be filtered with 80μm.

Lysimeter Quality Control Bag Liners

- Each time a new box of bag liners is opened, five (5) bags should be selected from it at random.
- Add 725 ml of best quality D.D.W. to each bag.
- Tie shut and allow to stand in a clean area for 48 hours and submit as normal lysimeter samples.

- Simultaneously submit two samples of the same D.D.W. used in the bag wash, using normal precipitation sample codes. If any contamination is found, contact supervisor immediately.

APPENDIX D: Ground Frost

Five stations at each of four Hawkeye groves (PO,BW,FB,PW) were utilized in monitoring ground frost and snow pack depth. A J99 soil increment core auger or Dutch auger were employed depending upon the thickness and intensity of the frozen soil. When the J99 core auger is used, the extracted core is evaluated and measured for frost penetration. If a Dutch auger is used, the depth of frost penetration is noted on the wall of the hole and then measured.

APPENDIX E: Tensiometers

- Install the porcelain tip on the tensiometer.

- Fill with ethylene glycol distilled water mixture capable of withstanding temperatures of -19°C.

- Withdraw air from around the regulator using a hand pump, zero and let stand for 48 hours to check for leaks.

- Install tensiometers at each grove, even with or slightly below the soil water leachate sites.

- Depth of installation will be in 15 cm increments to 90 cm,using a J99 soil increment auger.

- Soil from the auger tip is mixed with distilled water to form a paste. This paste is then formed around the porcelain tip, which creates a solid bond between the tensiometer and the soil horizon.

- Readings will be taken on a weekly basis. Pump the tube full from the reservoir, let equilibrate and read the gauge. This is the soil moisture reading recorded. During periods of high soil moisture, this reading should be done to zero.

- Ethylene glycol mixtures shall be disposed of at the Thunder Bay regional laboratory following all safe transportation procedures (WHMIS).

- Removal of tensiometers shall commence when daily temperature remains below -10°C.

MEAN DIFFERENCES AND STANDARD DEVIATIONS
BETWEEN LAB AND FIELD PH'S
AT HAWKEYE LAKE

DATE	MEAN	STDDEV
871125	-0.004	0.026
871214	-0.000	0.037
880118	-0.112	0.036
880120	-0.058	0.053
880218	-0.058	0.039
880317	0.034	0.021
880502	-0.092	0.027
880602	0.132	0.060
880621	-1.382	0.036
880629	0.012	0.132
880728	-0.006	0.040
880822	0.148	0.041
880824	0.028	0.175
880921	0.320	0.084
881003	0.256	0.041
881130	0.286	0.014
890220	0.040	0.062
890222	0.008	0.053
890322	0.200	0.042

Mean and Standard deviation of five
individual samples per date

Table 1

SUMMARY OF STATISTICS
FOR FOUR REPLICATE SITES IN THE HAWKEYE WATERSHED

	SITE A2			SITE EF12			SITE J21-22			SITE Q10		
	MEAN	C.V.	N	MEAN	C.V.	N	MEAN	C.V.	N	MEAN	C.V.	N
Alk	11.54	1.25	13	10.48	1.47	12	1.58	2.07	12	2.60	53.77	10
Al	274.93	3.66	14	375.21	11.46	13	466.92	5.08	13	371.36	4.27	11
Ca	6.43	1.52	14	5.30	1.06	13	4.81	1.88	13	5.23	1.63	11
Cl	0.34	10.86	14	0.32	6.95	13	0.37	10.65	13	0.32	8.52	11
Cond25	53.79	0.84	14	55.08	0.48	13	42.29	0.96	13	42.48	0.55	11
DOC	26.89	3.09	14	10.69	2.18	13	44.19	2.27	13	50.13	2.74	11
Fe	0.50	2.21	14	0.32	10.79	13	1.18	3.63	13	0.98	2.62	11
K	0.60	2.05	14	0.61	0.93	13	0.31	2.86	13	0.33	7.62	11
Mg	2.59	1.10	14	2.16	1.31	13	1.84	1.10	13	2.04	1.87	11
Mn	0.01	3.31	14	0.02	30.75	13	0.03	3.37	13	0.04	2.58	11
Na	1.33	1.89	14	1.43	1.79	13	1.07	2.12	13	1.10	2.75	11
NH4	34.47	1.59	14	13.65	0.67	13	30.19	4.75	13	40.46	10.92	11
NO3	300.49	2.65	14	292.81	10.86	13	154.79	11.97	13	188.36	5.91	11
TKN	815.89	2.28	14	412.88	6.01	13	917.60	7.39	13	1179.89	10.36	11
pH	6.59	0.45	14	6.49	0.35	13	4.87	0.29	13	4.95	0.34	11
P	12.93	5.88	38	13.62	18.71	26	25.08	9.79	26	18.71	7.59	22
Si	7.69	1.31	14	8.07	0.32	13	7.36	0.52	13	7.54	0.60	11
SO4	7.25	2.35	14	9.66	1.30	13	5.46	2.62	13	4.22	2.96	11

MEAN = Mean of the values for N number of days
C.V. = The mean of the coefficient of variance (%)
N = Number of sampling days this parameter sampled (four replicate samples per day)

Table 2

MONTHLY QUALITY CONTROL CHECKS
1987 TO 1989

	DISTILLED WATER		DISTILLED WATER IN BULK BAGS		DISTILLED WATER IN WET ONLY BAGS		DIFFERENCE BETWEEN DISTILLED WATER ONLY AND DISTILLED WATER IN BAGS	
	MEAN	S.D.	MEAN	S.D.	MEAN	S.D.	BULK	WET ONLY
ALK (mg/L)	–0.186	0.275	–0.247	0.215	–0.174	0.182	–0.061	0.012
Ca (mg/L)	0.008	0.025	0.001	0.005	0.012	0.037	–0.006	0.004
Cl (mg/L)	0.006	0.016	0.003	0.008	0.010	0.022	–0.003	0.004
Cond (umhos/cm)	1.800	2.078	2.042	1.641	1.743	1.474	0.242	–0.057
Fe (mg/L)	0.000	0.000	0.002	0.003			0.002	
K (mg/L)	0.002	0.008	0.002	0.006	0.011	0.041	0.000	0.009
Mg (mg/L)	0.001	0.005	0.000	0.001	0.002	0.010	–0.001	0.001
Mn (mg/L)	0.000	0.000	0.000	0.001			0.000	
Na (mg/L)	0.002	0.007	0.002	0.003	0.003	0.010	–0.000	0.001
NH4 (ug/L)	8.000	11.662	8.125	14.128	6.429	11.406	0.125	–1.571
NO3 (ug/L)	1.760	3.024	2.073	3.349	2.054	3.429	0.313	0.294
TKN (ug/L)	24.375	52.911	22.000	23.367	36.429	85.991	–2.375	12.054
pH	5.399	0.188	5.433	0.253	5.422	0.152	0.034	0.023
P (ug/L)	0.540	0.877	0.172	0.367	0.525	0.866	–0.368	–0.015
Si (mg/L)	0.001	0.005	0.002	0.008	0.000	0.000	0.001	–0.001
SO4 (mg/L)	0.063	0.154	0.013	0.027	0.048	0.108	–0.050	–0.015

Table 3

PRECIPITATION HKP8
WET ONLY TRACE METALS

SAMPLING DATE	Cd (ug/L)	Pb (ug/L)	Zn (ug/L)	Cu (ug/L)
27-DEC-88	0.114	0.65	2.37	1.4
02-JAN-89	0.010	0.56	1.32	1.0
09-JAN-89	0.065	0.76	1.69	0.6
12-JAN-89	0.036	0.75	2.07	0.9
19-JAN-89	0.009	0.39	2.09	1.7
13-FEB-89	0.022	0.44	1.01	0.7
01-MAR-89	0.092	0.83	3.31	0.7
13-MAR-89	0.000	0.80	1.68	0.9
03-APR-89	0.000	0.31	0.64	1.3
05-APR-89	0.025	0.21	0.00	1.4
10-APR-89	0.074	0.27	1.34	0.5
07-MAY-89		2.79	1.64	1.2
23-MAY-89	0.036	0.75	0.52	0.9
25-MAY-89	0.036	0.68	0.65	2.3

FIELD BAG BLANKS

SAMPLING DATE	Cd (ug/L)	Pb (ug/L)	Zn (ug/L)	Cu (ug/L)
28-FEB-89	0.010	0.00	0.00	0.5
13-MAR-89	0.020	0.00	1.76	3.1
30-MAR-89	0.000	0.00	2.90	0.7
07-APR-89	0.000	0.00	0.00	1.9
14-APR-89	0.020	0.00	0.00	0.3
24-APR-89	0.010	0.00	0.00	1.0
01-MAY-89	0.010	0.00	0.00	0.5
08-MAY-89	0.000	0.00	0.00	0.9
19-MAY-89	0.028	0.00	0.00	1.6
23-MAY-89	0.023	0.00	0.00	0.7

Table 4

LYSIMETER – HKZ01A

SAMPLING DATE	COND25 (umhos/cm)	pH	Alk (mg/L)	DOC (mg/L)	Ca (mg/L)	Mg (mg/L)	Na (mg/L)	K (mg/L)	NH4 (ug/L)	NO3 (ug/L)	SO4 (mg/L)	Cl (mg/L)	Fe (mg/L)	Al (mg/L)	Mn (mg/L)	Zn (mg/L)	Si (mg/L)
24-JUN-87		5.27		28.0	3.9	1.00	0.82	1.84	50	25	3.00	1.05	0.35	660	0.017	16.0	
03-JUL-87		6.48			6.9	1.58	1.48	7.19	30	30	4.70	1.50					
03-MAY-89	66	6.63	15.0	3.1	5.2	2.40	3.30	0.58	10	55	10.36	1.50	0.11		0.003	8.4	
05-MAY-89	65	6.93	14.5	3.3	4.9	2.24	3.84	0.62	10	255	9.43	0.97	0.21	230	0.010	5.9	
08-MAY-89	66	6.58	16.4	3.4	5.2	2.40	3.46	0.63	10	45	10.32	1.34	0.12	120	0.004	7.1	
MEDIAN	66	6.58	15.0	3.4	5.2	2.24	3.30	0.63	10	45	9.43	1.34	0.17	230	0.007	7.8	

LYSIMETER – HKZ01B2

SAMPLING DATE	COND25 (umhos/cm)	pH	Alk (mg/L)	DOC (mg/L)	Ca (mg/L)	Mg (mg/L)	Na (mg/L)	K (mg/L)	NH4 (ug/L)	NO3 (ug/L)	SO4 (mg/L)	Cl (mg/L)	Fe (mg/L)	Al (mg/L)	Mn (mg/L)	Zn (mg/L)	Si (mg/L)
25-APR-89	6								20	15							
03-MAY-89	6								20	10							
MEDIAN	6								20	13							

LYSIMETER – HKZ01BC

SAMPLING DATE	COND25 (umhos/cm)	pH	Alk (mg/L)	DOC (mg/L)	Ca (mg/L)	Mg (mg/L)	Na (mg/L)	K (mg/L)	NH4 (ug/L)	NO3 (ug/L)	SO4 (mg/L)	Cl (mg/L)	Fe (mg/L)	Al (mg/L)	Mn (mg/L)	Zn (mg/L)	Si (mg/L)
24-JUN-87		6.38		3.6	4.1		1.42	0.67	20	10	7.10	2.00	0.58	514	0.016	15.0	
25-APR-89	44	6.59	8.22	3.4	3.7	2.10	0.72	0.19			5.70	1.82	0.05	39	0.000	45.0	
28-APR-89	39	6.63	6.69	2.3	3.4	1.74	0.64	0.19	10	0	6.82	1.43	0.03	32	0.001	5.5	
01-MAY-89	40	6.54	7.62	2.2	3.4	1.70	0.70	0.22	10	0	6.48	1.32	0.18	130	0.002	2.9	
03-MAY-89	38	6.58	7.78	2.2	3.6	1.88	0.58	0.27	10	0	6.28	1.20	0.04	34	0.001	2.2	
05-MAY-89	41	6.60	8.72	2.6	3.8	2.00	0.66	0.27	10	0	5.73	1.39	0.04	30	0.001	2.2	
08-MAY-89	39	6.52	8.35	2.6	3.6	1.84	0.66	0.30	10	0	6.72	1.04	0.03	29	0.001	1.9	
10-MAY-89	41	6.47	8.28	2.5	3.4	1.72	0.68	0.28	10	0	6.81	0.40	0.04	29	0.001	2.8	
MEDIAN	40	6.56	8.22	2.6	3.6	1.84	0.67	0.27	10	0	6.60	1.35	0.04	33	0.001	2.9	

Table 5

LYSIMETER – HKZ01L

SAMPLING DATE	COND25 (umhos/cm)	pH	Alk (mg/L)	DOC (mg/L)	Ca (mg/L)	Mg (mg/L)	Na (mg/L)	K (mg/L)	NH4 (ug/L)	NO3 (ug/L)	SO4 (mg/L)	Cl (mg/L)	Fe (mg/L)	Al (mg/L)	Mn (mg/L)	Zn (mg/L)	Si (mg/L)
24-JUN-87		4.92		23.9	3.0	0.74	0.76	2.92	40	15	5.30	0.95	0.23	299	0.028	0.0	
24-JUN-87		4.96		30.0	4.1	0.94	0.66	2.99	40	17	3.80	1.00	0.29	416	0.034	13.0	
09-OCT-87		4.93							260	86							
18-OCT-87		5.02		190.0	25.2	5.36	0.94	5.79	720	58	6.20	7.10					6.60
17-NOV-87		5.26															
23-NOV-87																	
13-APR-88									2900	440							
18-APR-88																	
25-MAY-88		5.37															
21-JUN-88		4.43								250							
12-JUL-88		5.75															
02-AUG-88		5.66	6.07	24.5	3.7	0.96	0.06	4.58	680	155	1.90	0.69	0.12	130	0.020	32.0	
09-AUG-88		5.86															
16-AUG-88		5.74															
23-AUG-88		5.78															
05-APR-89									1400	175							
MEDIAN		5.31	6.07	27.3	3.9	0.95	0.71	3.78	680	121	4.55	0.97	0.23	299	0.028	13.0	6.60

LYSIMETER – HKZ02A

SAMPLING DATE	COND25 (umhos/cm)	pH	Alk (mg/L)	DOC (mg/L)	Ca (mg/L)	Mg (mg/L)	Na (mg/L)	K (mg/L)	NH4 (ug/L)	NO3 (ug/L)	SO4 (mg/L)	Cl (mg/L)	Fe (mg/L)	Al (mg/L)	Mn (mg/L)	Zn (mg/L)	Si (mg/L)
22-MAY-87		5.90															
03-JUL-87		5.62							210	50	4.90	1.10					
MEDIAN		5.76							210	50	4.90	1.10					

Table 5 continued

LYSIMETER – HKZ02B2

SAMPLING DATE	COND25 (umhos/cm)	pH	Alk (mg/L)	DOC (mg/L)	Ca (mg/L)	Mg (mg/L)	Na (mg/L)	K (mg/L)	NH4 (ug/L)	NO3 (ug/L)	SO4 (mg/L)	Cl (mg/L)	Fe (mg/L)	Al (mg/L)	Mn (mg/L)	Zn (mg/L)	Si (mg/L)
13-APR-88		6.35															
31-MAY-88		6.60															
14-JUN-88		6.16															
21-JUN-88		5.24															
28-JUN-88		6.12															
05-JUL-88		6.36															
12-JUL-88		6.08															
12-JUL-88																	
25-JUL-88		5.56															
02-AUG-88		6.04															
16-AUG-88		5.79															
25-MAY-89		6.27		3.1	1.6	0.70	0.84	0.33	0	0	4.70	0.61					4.28
MEDIAN		6.12		3.1	1.6	0.70	0.84	0.33	0	0	4.70	0.61					4.28

LYSIMETER – HKZ02BC

SAMPLING DATE	COND25 (umhos/cm)	pH	Alk (mg/L)	DOC (mg/L)	Ca (mg/L)	Mg (mg/L)	Na (mg/L)	K (mg/L)	NH4 (ug/L)	NO3 (ug/L)	SO4 (mg/L)	Cl (mg/L)	Fe (mg/L)	Al (mg/L)	Mn (mg/L)	Zn (mg/L)	Si (mg/L)
25-JUL-88		5.93															
02-AUG-88		6.42															
16-AUG-88		6.11															
17-NOV-88		5.99		14.5	2.7	0.90	0.44	0.90	20	135	4.00	1.35	0.05	310	0.000	51.0	
MEDIAN		6.05		14.5	2.7	0.90	0.44	0.90	20	135	4.00	1.35	0.05	310	0.000	51.0	

Table 5 continued

LYSIMETER – HKZ02L

SAMPLING DATE	COND25 (umhos/cm)	pH	Alk (mg/L)	DOC (mg/L)	Ca (mg/L)	Mg (mg/L)	Na (mg/L)	K (mg/L)	NH4 (ug/L)	NO3 (ug/L)	SO4 (mg/L)	Cl (mg/L)	Fe (mg/L)	Al (mg/L)	Mn (mg/L)	Zn (mg/L)	Si (mg/L)
30-JUN-87		6.38							30	30							
03-JUL-87		5.60		34.0	4.5	0.76		5.17	140	20	3.80	0.70	0.13	225	0.029	34.0	
18-OCT-87		5.08															
07-APR-88		4.94		55.0	10.0	1.98	0.52	8.29	280	137	14.80	5.25					1.84
12-APR-88				46.0	6.5	1.20	0.40	6.08	110	70	6.40	1.86	0.18	400	0.054	20.0	
13-APR-88		5.90															
03-MAY-88		5.77															
10-MAY-88		5.57							570								
25-MAY-88		5.18															
31-MAY-88		5.40							60	10							
14-JUN-88		5.23							1200	1350							
15-JUN-88											1.70	0.25					
21-JUN-88		5.01		86.0	5.3	1.10	0.48	11.90	90	95	7.67	1.80	0.19	420	0.066	28.0	
28-JUN-88		5.67							150								
05-JUL-88		5.52															
12-JUL-88		6.47		34.0	4.1	1.08	0.38	12.90	2100	960	5.78	2.28	0.10	330	0.033	38.0	
18-JUL-88		5.59			7.4	1.22	0.44	10.90	680	690	5.91	0.05					
25-JUL-88		4.96															
02-AUG-88		5.59	5.26	28.5	3.4	0.84	0.24	7.13	370	125	3.69	0.71	0.13	230	0.044	71.0	
09-AUG-88		5.42		78.0	9.1	1.60	0.36	10.60	310		3.94	1.34					1.22
16-AUG-88		5.27		18.0	8.9	1.48	0.36	9.20	480	45	5.01	1.24	0.23	700	0.046	34.0	
17-AUG-88		5.23							230	65							
23-AUG-88		5.25							410	125							
02-SEP-88				48.0	7.4	1.12	0.22	6.35	130	110	4.71	1.17	0.23	570	0.041	130.0	
20-SEP-88				51.5	8.5	1.34	0.20	5.35	300	50	5.64	0.88					1.06
18-OCT-88		5.32							50	25							
25-OCT-88		5.34															
17-NOV-88		5.59			3.2	0.70	0.22	4.44	90	585	5.39	2.26					
17-APR-89		6.22			4.7	0.98	0.26	6.54	50	115	4.59	1.33					
21-APR-89		6.53			5.3	0.90	0.24	6.29	30	10	3.46	1.04					

Table 5 continued

LYSIMETER – HKZ02L (cont'd)

SAMPLING DATE	COND25 (umhos/cm)	pH	Alk (mg/L)	DOC (mg/L)	Ca (mg/L)	Mg (mg/L)	Na (mg/L)	K (mg/L)	NH4 (ug/L)	NO3 (ug/L)	SO4 (mg/L)	Cl (mg/L)	Fe (mg/L)	Al (mg/L)	Mn (mg/L)	Zn (mg/L)	Si (mg/L)
25-APR-89	31	6.40		14.4	3.0	0.54	0.12	3.99	20	0	1.00	0.53	0.04	94	0.009	46.0	
28-APR-89		6.58	7.39	10.8	2.3	0.48	0.10	3.33	80	5	1.53	0.44	0.02	74	0.002	4.6	
25-MAY-89		6.23			4.4	0.78	0.22	4.14	430	5	4.53	0.51					
MEDIAN	31	5.57	6.32	40.0	5.3	1.08	0.25	6.35	150	68	4.65	1.10	0.13	330	0.041	34.0	1.22

Table 5 continued

LYSIMETER – HKZ02B1

SAMPLING DATE	COND25 (umhos/cm)	pH	Alk (mg/L)	DOC (mg/L)	Ca (mg/L)	Mg (mg/L)	Na (mg/L)	K (mg/L)	NH4 (ug/L)	NO3 (ug/L)	SO4 (mg/L)	Cl (mg/L)	Fe (mg/L)	Al (mg/L)	Mn (mg/L)	Zn (mg/L)	Si (mg/L)
07-APR-88		4.97															
12-APR-88									380	130	4.80	1.48					
13-APR-88									20	310							
13-MAY-88		6.81															
25-MAY-88																	
31-MAY-88		6.19															
14-JUN-88		5.92								190							
28-JUN-88		5.89															
12-JUL-88		5.83															
25-JUL-88		5.23															
02-AUG-88		5.40			2.3	0.82	0.38	0.87	30	5	3.52	0.68					
16-AUG-88		5.57															
17-AUG-88		6.09															
23-AUG-88		5.94															
MEDIAN		5.89			2.3	0.82	0.38	0.87	30	160	4.16	1.08					

Table 5 continued

LYSIMETER – HKZ03A

SAMPLING DATE	COND25 (umhos/cm)	pH	Alk (mg/L)	DOC (mg/L)	Ca (mg/L)	Mg (mg/L)	Na (mg/L)	K (mg/L)	NH4 (ug/L)	NO3 (ug/L)	SO4 (mg/L)	Cl (mg/L)	Fe (mg/L)	Al (mg/L)	Mn (mg/L)	Zn (mg/L)	Si (mg/L)
01-APR-87		5.78		12.9	1.3	0.38	1.42	3.68	50	18	2.30	1.00	0.04	160	0.013	7.0	
27-MAY-87		6.50		40.5	6.8	2.16	18.80	11.70	360	1500	16.80	6.15					0.06
02-JUN-87		6.30		47.5					30	110	6.50	6.20					0.08
09-JUN-87		6.24			2.4	0.54	15.00	5.03	20	29	3.80	4.70					
03-JUL-87		5.58		25.5	2.1	0.68	2.50	7.20	30	30	5.20	1.40	0.48	810	0.113	580.0	
18-OCT-87		5.43		47.0	9.4	2.74	0.42	0.95	20	39	1.20	12.70					2.90
17-NOV-87		5.87															
29-MAR-88		5.26		15.0	8.1	2.56	0.84	2.34	30	2600	14.00	1.87	0.14	250	0.034	4.0	
05-APR-88		5.68		20.0	5.6	1.68	0.48	1.23	20	343	7.80	0.70					
07-APR-88		5.55		31.0	5.5	1.70	0.42	1.27	30	421	6.00	0.90	0.22	480	0.011	87.0	
12-APR-88		5.79	4.82	32.0	4.6	1.42	0.36	1.24	20	15	3.60	0.69	0.32	570	0.012	12.0	
13-APR-88		5.87		15.6	2.6	0.82	0.22	0.83	40	97	1.60	0.26	0.14	270	0.005	11.0	
15-APR-88		5.20							10	90							
03-MAY-88		3.66															
10-MAY-88		5.89															
25-MAY-88		6.01															
31-MAY-88		6.21									7.10	1.52					
08-JUN-88		6.12								55							
14-JUN-88		6.01															
21-JUN-88		5.17		13.5	4.3	1.34	0.50	3.01	70		5.16	1.01	0.17	270	0.016	35.0	
28-JUN-88		6.05															
05-JUL-88		6.34															
12-JUL-88				26.8	4.7	1.64	0.48	6.05	660	325	5.49	1.38	0.71	1400	0.130	37.0	
18-JUL-88		5.85															
02-AUG-88		5.65	4.57	16.8	3.1	1.04	0.22	2.57	90	55	3.07	0.65	0.96	990	0.033	38.0	
03-AUG-88		5.82		21.0	3.3	1.02	0.30	1.38	40	340	2.42	0.51					
09-AUG-88		5.98							80	20							
16-AUG-88		5.74		15.5	4.2	1.28	0.34	1.26	130	90	2.10	0.54					1.60
23-AUG-88		6.02															
18-OCT-88		5.75															

Table 5 continued

LYSIMETER – HKZ03A (cont'd)

SAMPLING DATE	COND25 (umhos/cm)	pH	Alk (mg/L)	DOC (mg/L)	Ca (mg/L)	Mg (mg/L)	Na (mg/L)	K (mg/L)	NH4 (ug/L)	NO3 (ug/L)	SO4 (mg/L)	Cl (mg/L)	Fe (mg/L)	Al (mg/L)	Mn (mg/L)	Zn (mg/L)	Si (mg/L)
25-OCT-88					6.5	2.04	1.32	1.07			6.15	1.21					
25-OCT-88		5.60															
17-NOV-88	13	5.57	1.19	7.0	1.1	0.36	0.08	0.77	10	155	1.48	0.02	0.11	140	0.000	16.0	
04-APR-89	52	5.73	4.35	24.5	5.8	1.76	0.40	1.38	70	745	10.10	1.01	0.35	550	0.012	17.0	
07-APR-89	43	5.77	4.11	21.7	5.2	1.48	0.44	1.32	40	685	6.38	0.75	0.28	480	0.005	9.0	
18-APR-89		5.73			5.3	1.50	0.44	1.75	50	85	3.44	0.41					
25-APR-89		5.90		31.0	4.3	1.10	0.58	1.30	30	5	1.97	0.26					2.18
MEDIAN	43	5.79	4.35	21.7	4.6	1.42	0.44	1.38	40	90	5.16	1.00	0.25	480	0.013	16.5	1.60

LYSIMETER – HKZ03B1

SAMPLING DATE	COND25 (umhos/cm)	pH	Alk (mg/L)	DOC (mg/L)	Ca (mg/L)	Mg (mg/L)	Na (mg/L)	K (mg/L)	NH4 (ug/L)	NO3 (ug/L)	SO4 (mg/L)	Cl (mg/L)	Fe (mg/L)	Al (mg/L)	Mn (mg/L)	Zn (mg/L)	Si (mg/L)
18-OCT-87		6.02							40	89	0.80	6.10					
05-APR-88		6.25							510	328	12.00	2.64					
07-APR-88		5.87		31.0	8.3	3.02	0.78	0.38	70	63	14.60	3.55					3.80
12-APR-88				30.5	6.6	2.44	0.60	0.34	60	17	11.60	1.24					3.40
13-APR-88									50	87	4.40	0.41					
28-APR-88		5.23															
31-MAY-88		6.28															
21-JUN-88		5.29		23.6	5.1	1.72	0.58	1.01	20		6.02	1.12					
02-AUG-88		6.14		17.8	3.9	1.24	0.42	0.62	50	110	3.95	0.75	0.50	540	0.010	120.0	
03-AUG-88		6.16							60	30							
16-AUG-88		5.73															
27-APR-89		5.98							230	200							
MEDIAN		6.00		27.1	5.9	2.08	0.59	0.50	60	88	6.02	1.24	0.50	540	0.010	120.0	3.60

Table 5 continued

LYSIMETER – HKZ03B2

SAMPLING DATE	COND25 (umhos/cm)	pH	Alk (mg/L)	DOC (mg/L)	Ca (mg/L)	Mg (mg/L)	Na (mg/L)	K (mg/L)	NH4 (ug/L)	NO3 (ug/L)	SO4 (mg/L)	Cl (mg/L)	Fe (mg/L)	Al (mg/L)	Mn (mg/L)	Zn (mg/L)	Si (mg/L)
07-APR-88		6.15		30.0	6.1	2.96	0.64	0.48	360	78	12.00						
12-APR-88									40	27							
13-APR-88				27.0	5.6	2.28	0.54	0.29	100	83	9.00	0.74					
06-JUN-88		6.42															
14-JUN-88		6.45															
21-JUN-88		5.36															
05-JUL-88		6.38															
12-JUL-88		6.35							160								
02-AUG-88		5.98	7.32	21.5	5.0	1.90	0.48	0.75	10	95	4.89	0.79	0.31	850	0.005	36.0	
03-AUG-88		6.57		18.4	4.7	1.92	0.54	0.38	70	15	4.98	0.47	0.23	670	0.003	27.0	
04-AUG-88		5.49															
16-AUG-88		6.19		21.0	6.8	2.54	0.52	0.52	50	940	3.44	0.52					2.46
06-SEP-88									60	360							
25-APR-89		7.48							40000	6040							
MEDIAN		6.35	7.32	21.5	5.6	2.28	0.54	0.48	70	89	4.98	0.63	0.27	760	0.004	31.5	2.46

Table 5 continued

LYSIMETER – HKZ03L

SAMPLING DATE	COND25 (umhos/cm)	pH	Alk (mg/L)	DOC (mg/L)	Ca (mg/L)	Mg (mg/L)	Na (mg/L)	K (mg/L)	NH4 (ug/L)	NO3 (ug/L)	SO4 (mg/L)	Cl (mg/L)	Fe (mg/L)	Al (mg/L)	Mn (mg/L)	Zn (mg/L)	Si (mg/L)
09-OCT-87		5.27							30	57							
18-OCT-87		5.41		92.0	12.5	3.28	0.50	7.84	40	44	1.60		0.73	1400	0.090	24.0	
17-NOV-87		5.40							200	115							
23-NOV-87		6.20															
07-APR-88		5.75															
12-APR-88									1100	140							
13-APR-88				43.0	4.3	1.30	0.36	2.74			2.80	0.83					
25-APR-88		5.75															
03-MAY-88		5.91															
10-MAY-88		5.51															
31-MAY-88		5.49									6.00	1.18					
06-JUN-88		5.90															
14-JUN-88		5.63															
21-JUN-88		4.72		17.0	3.9	1.26	0.36	4.61	630	790	4.74	1.07	0.21	380	0.042	23.0	
12-JUL-88		6.53		25.0	4.2	1.54	0.42	5.60	500	355	4.25	1.06					0.02
18-JUL-88		5.53															
02-AUG-88		5.59	2.99	17.5	2.8	0.94	0.14	2.49	210	240	2.32	0.48	0.30	380	0.036	52.0	
03-AUG-88		5.66							90	120	1.94	0.30					
09-AUG-88		5.60		80.0	7.7	2.04	0.26	2.78	120	45	0.96	0.64					1.00
16-AUG-88		5.32		17.0	9.5	2.36	0.30	2.01	290	95	1.58	0.57	1.10	2300	0.055	62.0	
17-AUG-88		5.12							110								
23-AUG-88		5.25															
02-SEP-88				79.0	10.1	2.18	0.22	1.44	170	160	2.43	0.62					
20-SEP-88					13.6	2.86	0.28	1.40			4.38	1.41					
21-SEP-88									360	155							
18-OCT-88		5.42															
18-OCT-88											9.03	7.80					
25-OCT-88		5.21															
25-APR-89		5.57							60	260							
25-APR-89		5.35							160	115							

Table 5 continued

LYSIMETER – HKZ03L (cont'd)

SAMPLING DATE	COND25 (umhos/cm)	pH	Alk (mg/L)	DOC (mg/L)	Ca (mg/L)	Mg (mg/L)	Na (mg/L)	K (mg/L)	NH4 (ug/L)	NO3 (ug/L)	SO4 (mg/L)	Cl (mg/L)	Fe (mg/L)	Al (mg/L)	Mn (mg/L)	Zn (mg/L)	Si (mg/L)
23-MAY-89		5.68							350								
MEDIAN		5.53	2.99	34.0	7.7	2.04	0.30	2.74	185	130	2.61	0.83	0.51	890	0.049	38.0	0.51

LYSIMETER – HKZ04A

SAMPLING DATE	COND25 (umhos/cm)	pH	Alk (mg/L)	DOC (mg/L)	Ca (mg/L)	Mg (mg/L)	Na (mg/L)	K (mg/L)	NH4 (ug/L)	NO3 (ug/L)	SO4 (mg/L)	Cl (mg/L)	Fe (mg/L)	Al (mg/L)	Mn (mg/L)	Zn (mg/L)	Si (mg/L)
21-MAY-87		7.00		37.0	8.6	2.14	33.40	8.35	40	27	4.10	33.90					0.18
03-JUL-87		6.62			6.2	1.18	0.48	7.25	40	20	3.90	0.85					
07-APR-88		5.92			6.2	1.68	0.54	2.60	330	1400	4.60	1.25					
12-APR-88				32.5	4.6	1.14	0.48	1.00	90	51	3.00	1.02					
10-MAY-88		6.67															
25-MAY-88		6.25															
31-MAY-88		6.23															
08-JUN-88		6.47								10							
14-JUN-88		6.60															
21-JUN-88		5.06															
28-JUN-88																	
05-JUL-88		6.51															
12-JUL-88		5.56							230	465							
18-JUL-88		5.61															
25-JUL-88		5.92															
02-AUG-88		5.97		17.2	1.9	0.56	1.02	2.78	110	145	2.11	0.93	0.36	360	0.046	49.0	
09-AUG-88		5.27															
16-AUG-88		5.40															
06-SEP-88									380								
25-APR-89		5.54							100	20							
MEDIAN		5.97		32.5	6.2	1.18	0.54	2.78	105	39	3.90	1.02	0.36	360	0.046	49.0	0.18

Table 5 continued

LYSIMETER – HKZ04B1

SAMPLING DATE	COND25 (umhos/cm)	pH	Alk (mg/L)	DOC (mg/L)	Ca (mg/L)	Mg (mg/L)	Na (mg/L)	K (mg/L)	NH4 (ug/L)	NO3 (ug/L)	SO4 (mg/L)	Cl (mg/L)	Fe (mg/L)	Al (mg/L)	Mn (mg/L)	Zn (mg/L)	Si (mg/L)
07-APR-88		6.34		36.0	8.9	2.12	0.44	1.22	100	287	6.60	1.33					
12-APR-88									90	240							
18-JUL-88		6.15															
02-AUG-88		6.00		17.0	3.6	1.10	0.12	5.33	100	10	2.47	0.31	0.11	230	0.010	95.0	
09-AUG-88		6.35															
17-AUG-88		5.94															
17-NOV-88		6.24		25.0	6.1	1.34	0.40	1.29	20	165	4.37	0.89	1.00	1200	0.004	25.0	
MEDIAN		6.19		25.0	6.1	1.34	0.40	1.29	95	202	4.37	0.89	0.55	715	0.007	60.0	

LYSIMETER – HKZ04B2

SAMPLING DATE	COND25 (umhos/cm)	pH	Alk (mg/L)	DOC (mg/L)	Ca (mg/L)	Mg (mg/L)	Na (mg/L)	K (mg/L)	NH4 (ug/L)	NO3 (ug/L)	SO4 (mg/L)	Cl (mg/L)	Fe (mg/L)	Al (mg/L)	Mn (mg/L)	Zn (mg/L)	Si (mg/L)
07-APR-88		5.63			14.0	3.08	0.34	3.30	190	166	7.40	1.15					
12-APR-88		5.81															
12-APR-88		6.35							650	190							
13-APR-88		5.96															
06-JUN-88		6.56															
21-JUN-88		5.26															
28-JUN-88		6.08															
12-JUL-88											2.56	0.51					
02-AUG-88		6.49		18.0	5.8	1.44	0.42	1.77	100	40	4.59	0.52					4.24
10-NOV-88		6.43															
17-NOV-88		5.85			4.8	1.00	0.22	4.50	90	105	3.91	0.54					
18-APR-89		5.96							20	20							
25-APR-89		6.18		16.3	4.0	0.66	0.28	1.59	100	20	1.84	0.16					2.26
MEDIAN		6.02		17.2	5.3	1.22	0.31	2.53	100	73	3.91	0.52					3.25

Table 5 continued

LYSIMETER – HKZ04BC

SAMPLING DATE	COND25 (umhos/cm)	pH	Alk (mg/L)	DOC (mg/L)	Ca (mg/L)	Mg (mg/L)	Na (mg/L)	K (mg/L)	NH4 (ug/L)	NO3 (ug/L)	SO4 (mg/L)	Cl (mg/L)	Fe (mg/L)	Al (mg/L)	Mn (mg/L)	Zn (mg/L)	Si (mg/L)
18-JUL-88		6.75															
25-JUL-88		5.99															
09-AUG-88		6.68															
MEDIAN		6.68															

LYSIMETER – HKZ04L

SAMPLING DATE	COND25 (umhos/cm)	pH	Alk (mg/L)	DOC (mg/L)	Ca (mg/L)	Mg (mg/L)	Na (mg/L)	K (mg/L)	NH4 (ug/L)	NO3 (ug/L)	SO4 (mg/L)	Cl (mg/L)	Fe (mg/L)	Al (mg/L)	Mn (mg/L)	Zn (mg/L)	Si (mg/L)
01-APR-87		6.16		36.5	9.5	2.06	18.50	8.06	30	19	2.90	29.20	0.13	150	0.036	20.0	
21-MAY-87		6.70		51.5	7.3	1.42	56.70	7.43	50	40	4.40	45.80	0.18	133	0.110	44.0	
27-MAY-87		6.60		36.5	3.5	0.70	34.00	3.45	40	33	2.90	27.80	0.09	70	0.025	44.0	
02-JUN-87		6.90		67.0					70	30	2.70	33.90	0.20	116	0.081	53.0	
09-JUN-87		6.90		58.5	2.3	0.36	44.90	3.44	50	29	2.50	29.10	0.17	98	0.048	41.0	
30-JUN-87		7.16		90.0	3.7	0.60	69.00	5.30	60	30	2.30	59.50					0.30
30-JUN-87		7.52															
03-JUL-87		6.45		33.0	2.6	0.46	18.40	4.87	40	20	3.50	9.80	0.08	63	0.014	25.0	
18-OCT-87		5.81		173.0					70	45							4.60
17-NOV-87		6.14															
07-APR-88		6.16			23.1	5.60	0.60	10.60	2000	7200	14.00	3.35					
12-APR-88					11.4	2.80	0.36	7.16	630	98	4.60	0.81					
03-MAY-88		6.35															
10-MAY-88		6.12							320								
25-MAY-88		6.24															
30-MAY-88		5.88							670	435							
31-MAY-88		5.96															
08-JUN-88		6.52							360	355							
14-JUN-88		6.02							20	20							
21-JUN-88		4.77		64.0	9.9	2.14	0.22	9.21	2000	1630	6.06	1.26	0.39	550	0.079	36.0	
28-JUN-88		6.42							130	1480							

Table 5 continued

LYSIMETER – HKZ04L (cont'd)

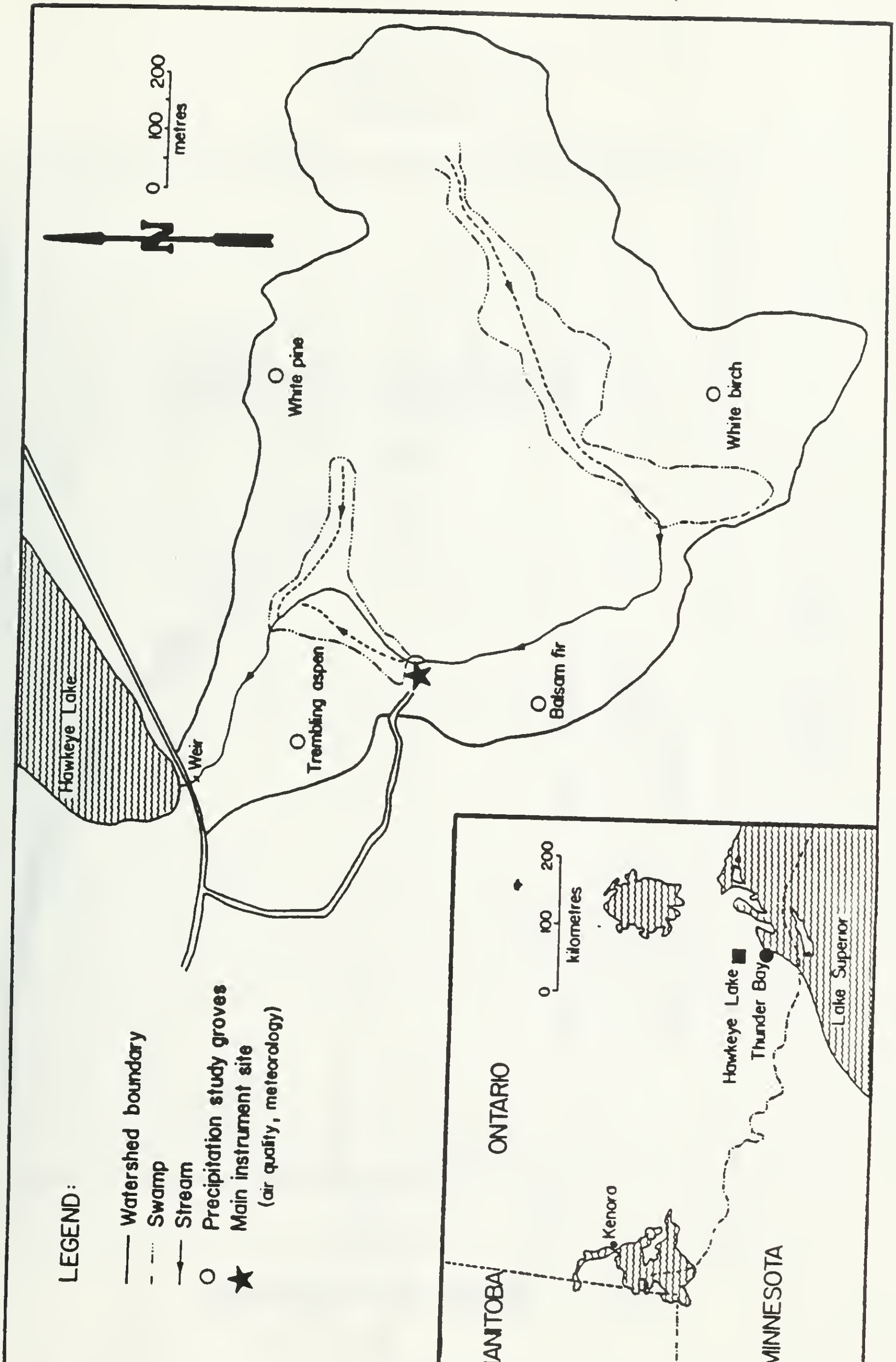
SAMPLING DATE	COND25 (umhos/cm)	pH	Alk (mg/L)	DOC (mg/L)	Ca (mg/L)	Mg (mg/L)	Na (mg/L)	K (mg/L)	NH4 (ug/L)	NO3 (ug/L)	SO4 (mg/L)	Cl (mg/L)	Fe (mg/L)	Al (mg/L)	Mn (mg/L)	Zn (mg/L)	Si (mg/L)
05-JUL-88		6.78															
12-JUL-88		6.48		29.0	4.7	1.16	0.32	7.49	400	390	3.15	0.80					0.22
18-JUL-88		5.66			17.9	3.66	0.28	10.60			4.57	0.06					
25-JUL-88		4.07															
02-AUG-88		5.83		18.0	3.7	0.92	0.10	4.60	700	735	2.53	0.45	0.23	190	0.029	49.0	
09-AUG-88		6.14		49.0	7.3	1.54	0.20	5.43	70		0.91	0.53					1.22
16-AUG-88		5.46		18.5	7.6	1.60	0.16	3.44	180	60	1.02	2.42					1.24
17-AUG-88		5.43							180	125							
23-AUG-88		5.72															
02-SEP-88				40.0	6.2	1.18	0.18	5.26	7200	440	2.28	0.41					1.08
20-SEP-88				30.5	5.0	1.08	0.22	3.48			3.00	0.86					1.44
21-SEP-88									100	90							
18-OCT-88		5.69							760								
25-OCT-88																	
17-NOV-88		5.50							60	25							
25-APR-89		5.51							240	95							
23-MAY-89		6.24							280	15	2.23	0.45					
25-MAY-89		5.56			10.0	1.82	0.26	8.80	80	30	1.06	0.19					
MEDIAN		6.14		40.0	7.3	1.42	0.32	5.43	155	60	2.90	1.26	0.17	125	0.042	42.5	1.22

Table 5 continued

LYSIMETER – HKZ05L

SAMPLING DATE	COND25 (umhos/cm)	pH	Alk (mg/L)	DOC (mg/L)	Ca (mg/L)	Mg (mg/L)	Na (mg/L)	K (mg/L)	NH4 (ug/L)	NO3 (ug/L)	SO4 (mg/L)	Cl (mg/L)	Fe (mg/L)	Al (mg/L)	Mn (mg/L)	Zn (mg/L)	Si (mg/L)
22-MAY-87		3.80		34.5	2.0	0.64	0.48	5.48	1100	41	9.50	1.95	0.10	118	0.099	30.0	
18-OCT-87		3.35															
23-NOV-87		3.21															
12-APR-88									770	400							
12-APR-88				129.0	2.6	0.62	1.12	3.79			12.80	1.62	0.55	660	0.150	16.0	
12-APR-88									1000	150							
13-APR-88									540								
03-MAY-88		4.33															
10-MAY-88		3.82															
12-MAY-88																	
14-JUN-88		4.13															
14-JUN-88		4.13			1.2	0.30	0.22	3.08	490	20	4.30	0.66					
21-JUN-88		3.18		145.0	5.2	1.08	0.92	13.30	1300	230	19.67	2.35	0.60	730	0.290	38.0	
05-JUL-88		4.42															
12-JUL-88		5.52							100	5							
18-JUL-88		3.39															
02-AUG-88		3.71		130.0	2.2	0.60	0.42	9.50	3700	110	6.32	2.10	0.72	680	0.110	82.0	
04-AUG-88		3.12			2.4	0.70	0.54	9.62	6000	70	6.47	2.10					
09-AUG-88		3.36		375.0	4.4	1.24	0.76	13.63		140	5.33	2.68	2.50	2100	0.170	110.0	
16-AUG-88		3.36															
23-AUG-88		3.52			4.7	0.96	0.90	2.45	8600	140	5.60	3.37					
02-SEP-88				233.0	3.4	0.72	0.56	13.00	460		6.37	2.70					0.66
18-OCT-88		3.63		1950	15.1	2.30	0.94	30.00	15000		27.65	25.0					
24-OCT-88		3.48															
17-NOV-88		3.71															
18-APR-89		4.31			3.8	0.70	0.56	14.60	6200	270	9.53	2.94					
25-APR-89		4.01			3.1	0.40	0.50	13.40	3900	95	3.94	1.11					
25-MAY-89		3.89			0.7	0.22	0.38	5.49	4530	60	3.95	0.62					
MEDIAN		3.71		145.0	3.1	0.70	0.56	9.62	1300	110	6.37	2.10	0.60	680	0.150	38.0	0.66

Table 5 continued



Hawkeye Lake Watershed Study Site.

Figure 1

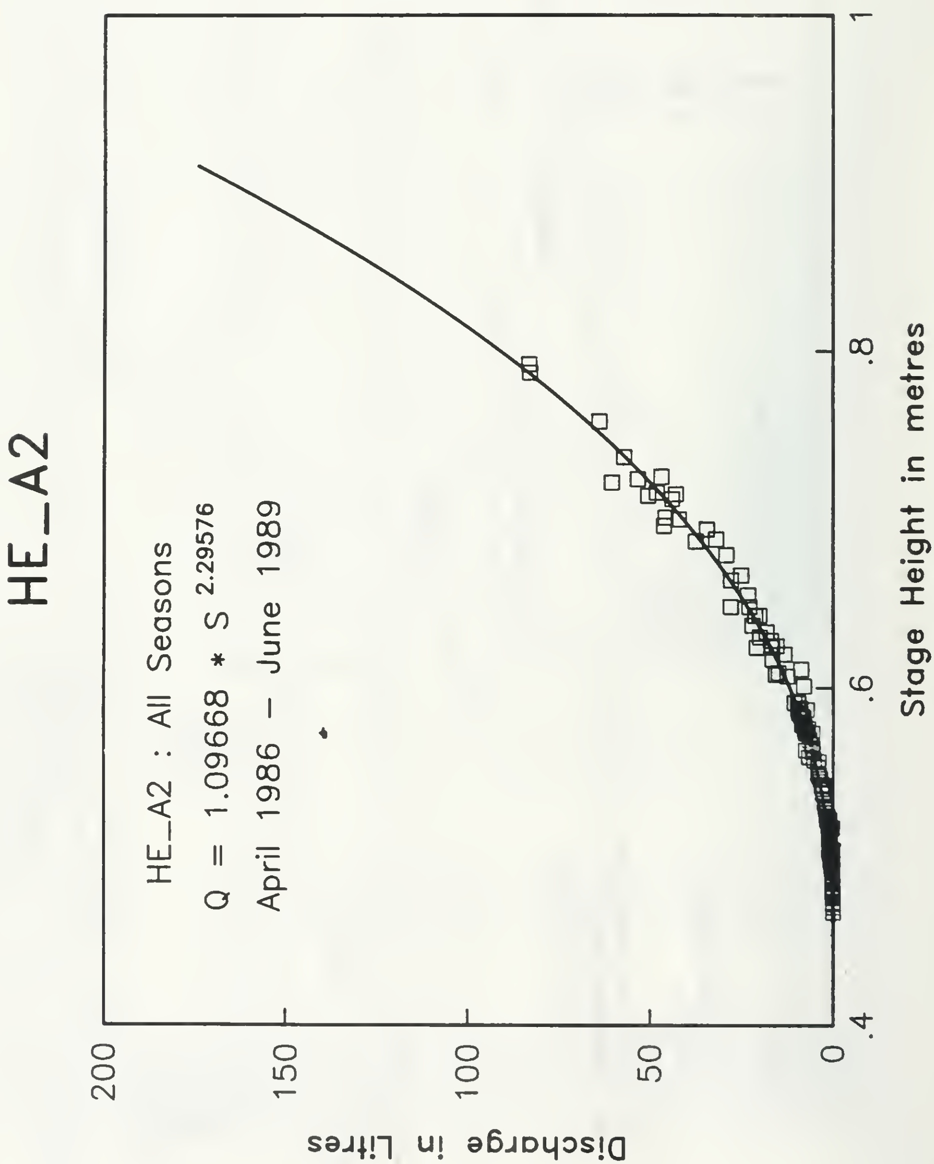
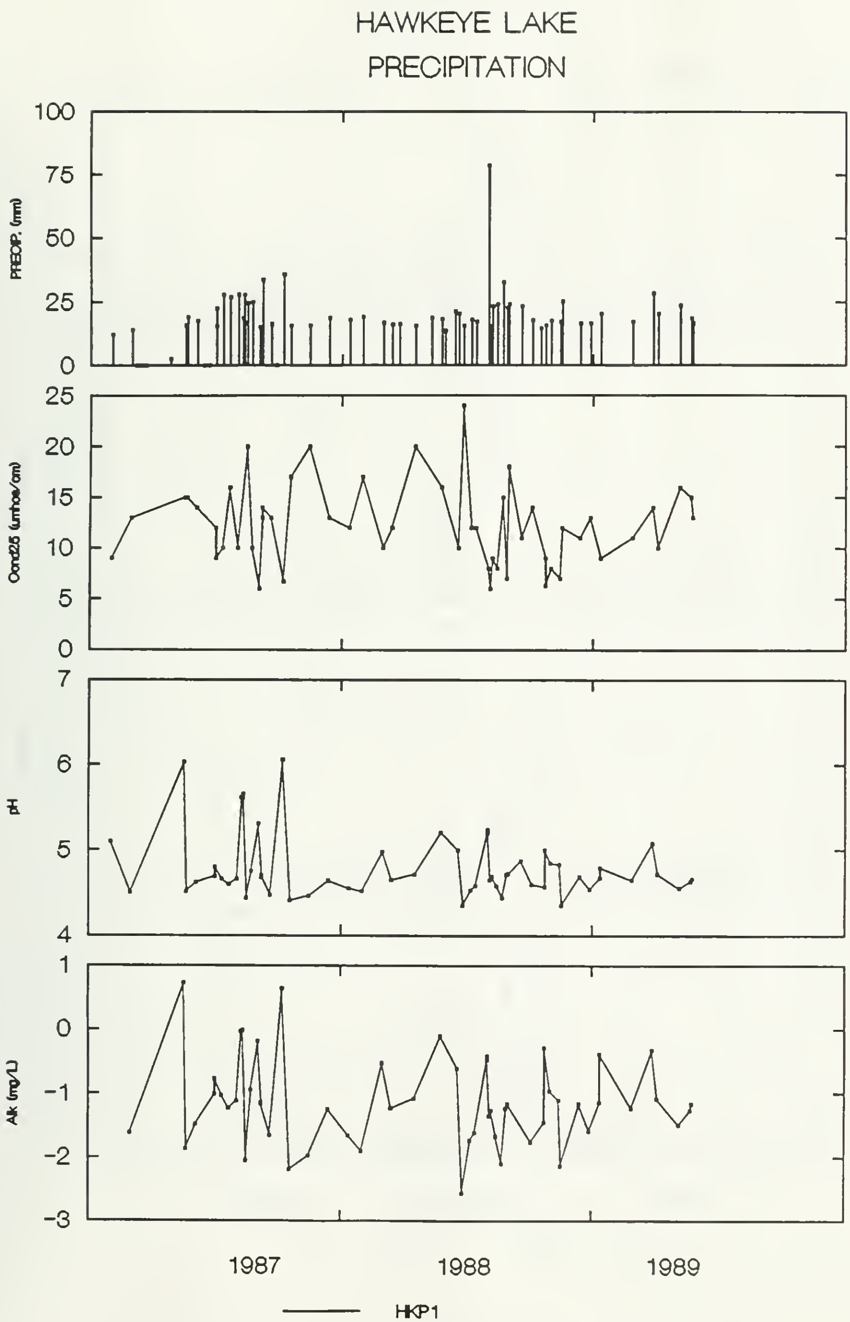

HE_A2
HE_A2 : All Seasons
Q = 1.09668 * S 2.29576
April 1986 – June 1989
Discharge in Litres
Stage Height in metres
0
50
100
150
200
.4
.6
.8
1

Figure 2


HAWKEYE LAKE
PRECIPITATION
PRECIP. (mm)
Cond25 (umhos/cm)
pH
Alk (mg/L)
1987
1988
1989
HKP1
Figure 3a

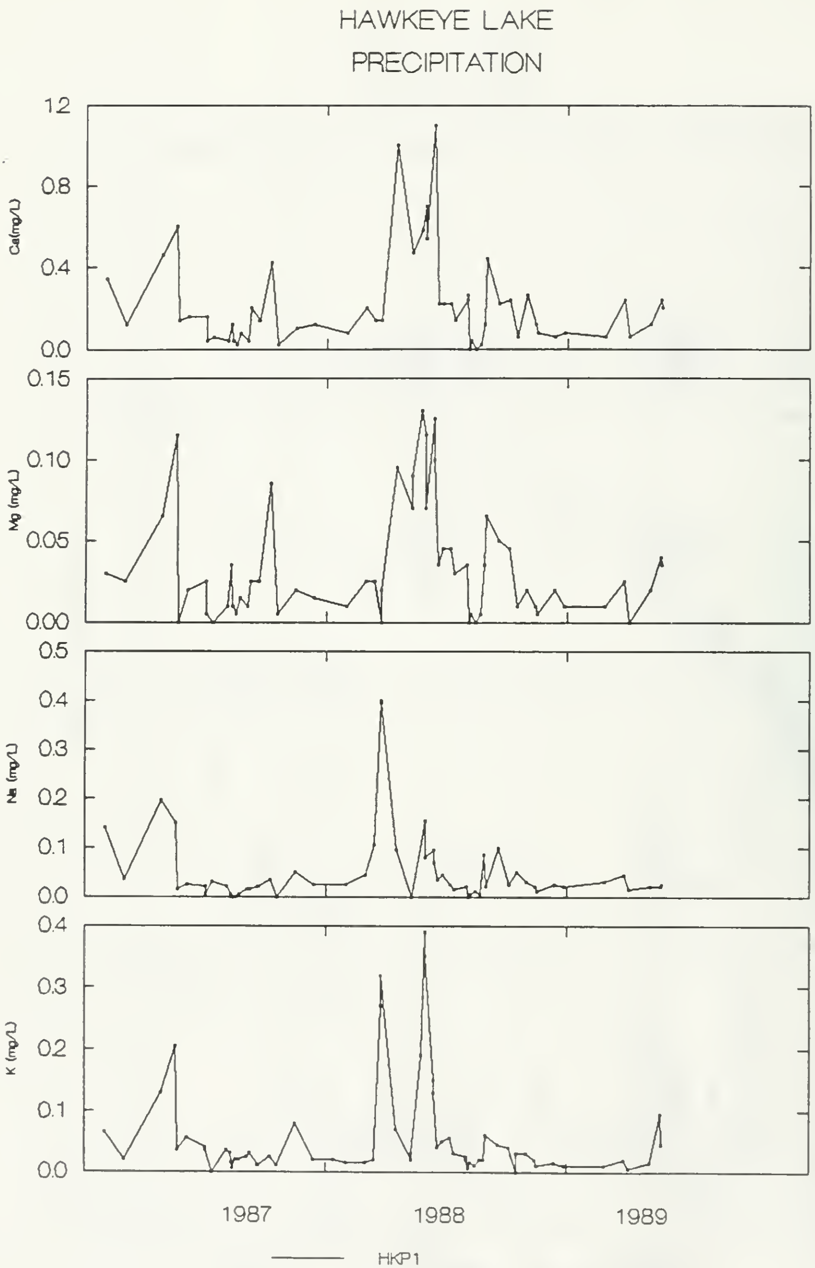
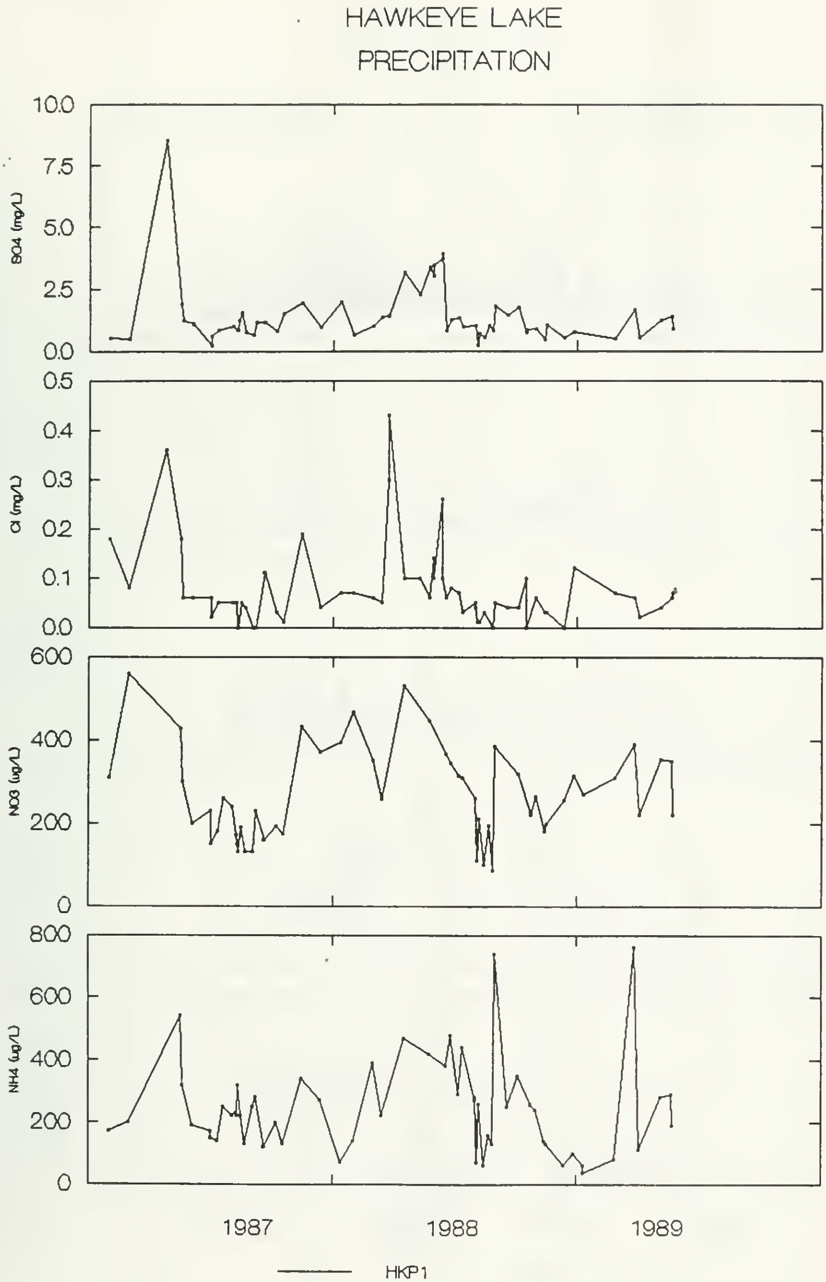

HAWKEYE LAKE
PRECIPITATION
Ca(mg/L)
1.2
0.8
0.4
0.0
Mg (mg/L)
0.15
0.10
0.05
0.00
Na (mg/L)
0.5
0.4
0.3
0.2
0.1
0.0
K (mg/L)
0.4
0.3
0.2
0.1
0.0
1987
1988
1989
HKP1

Figure 3b



HAWKEYE LAKE
PRECIPITATION
SO4 (mg/L)
10.0
7.5
5.0
2.5
0.0
Cl (mg/L)
0.5
0.4
0.3
0.2
0.1
0.0
NO3 (ug/L)
600
400
200
0
NH4 (ug/L)
800
600
400
200
0
1987
1988
1989
HKP1

Figure 3c

HAWKEYE LAKE

PRECIPITATION

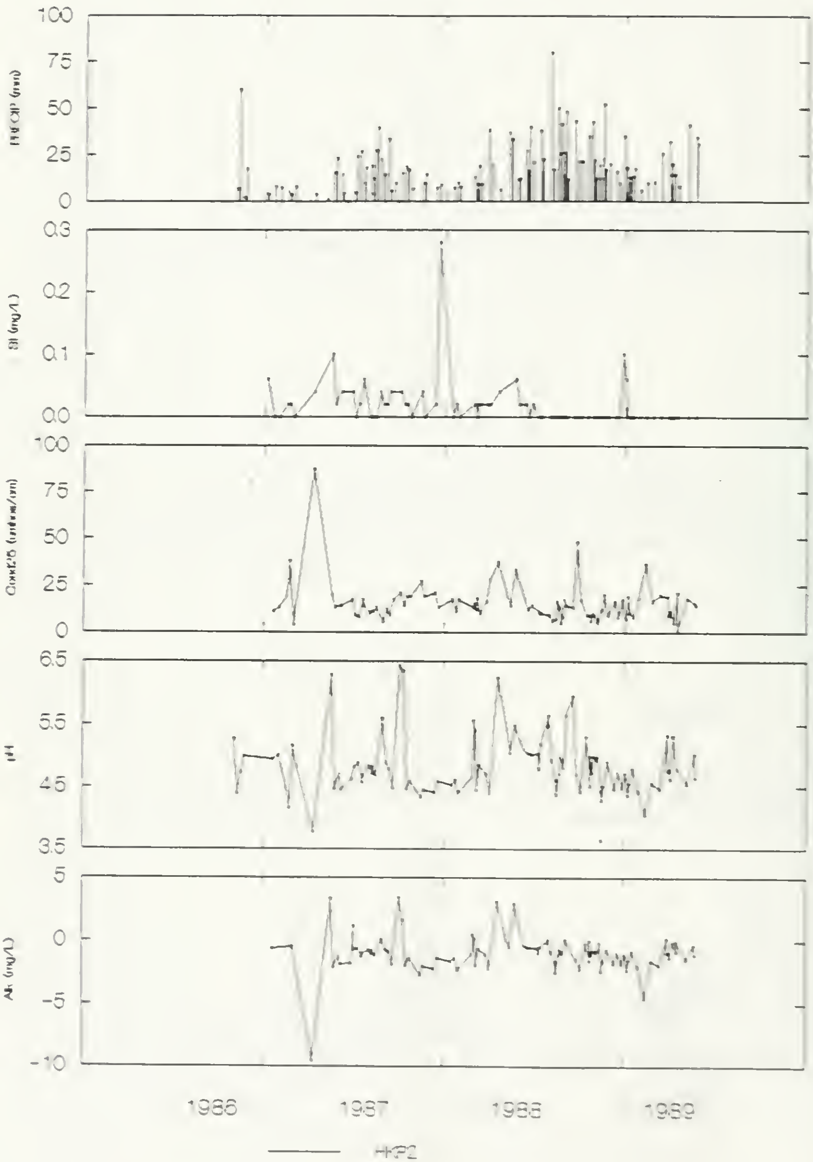


Figure 4a

HAWKEYE LAKE
PRECIPITATION

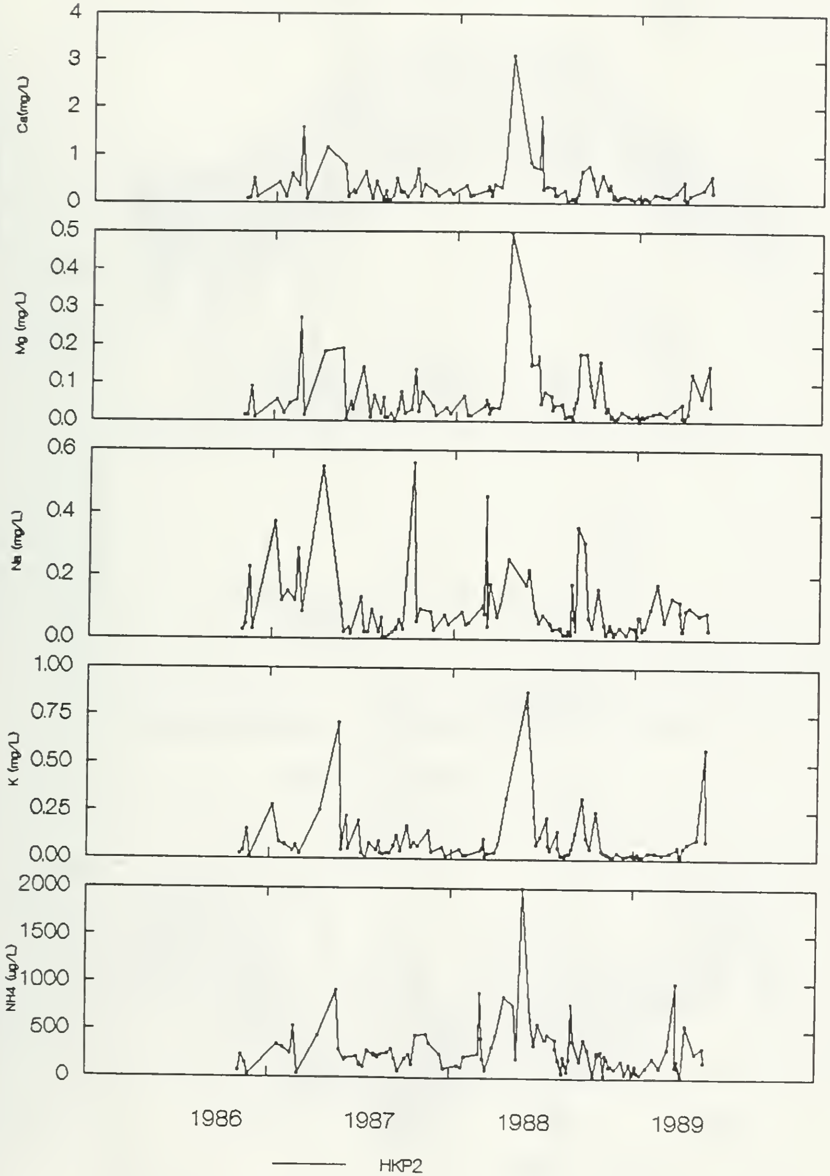


Figure 4b

HAWKEYE LAKE
PRECIPITATION

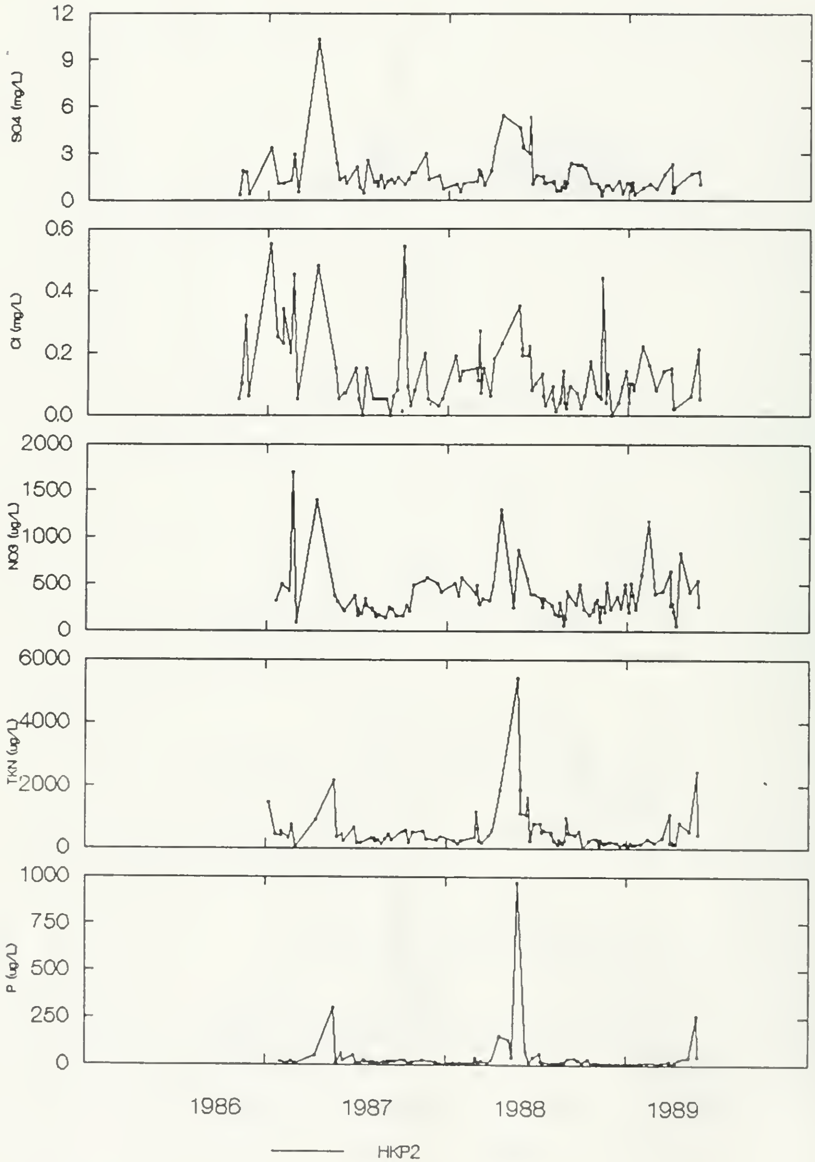


Figure 4c

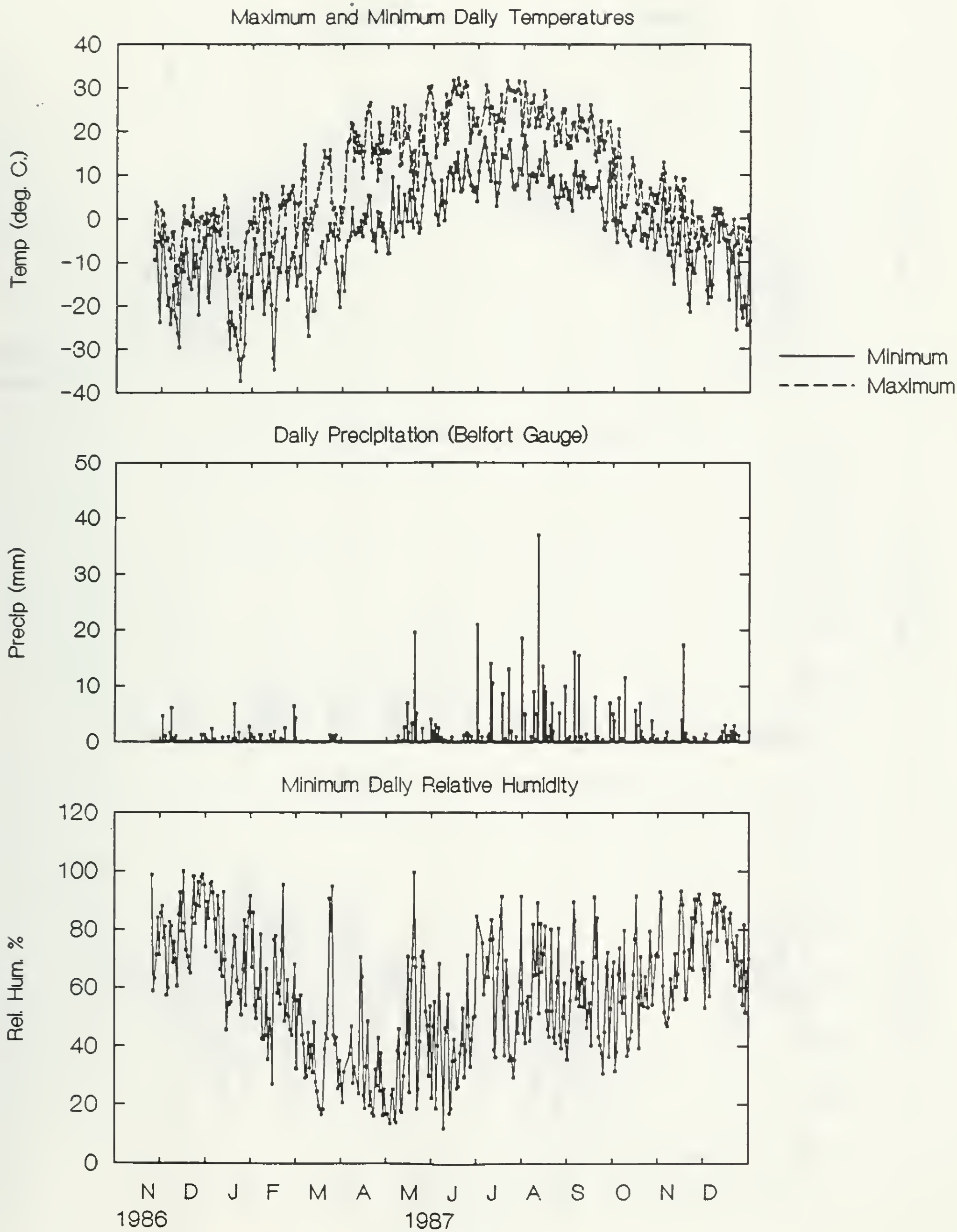

Maximum and Minimum Daily Temperatures
Temp (deg. C.)
40
30
20
10
0
-10
-20
-30
-40
Minimum
Maximum
Daily Precipitation (Belfort Gauge)
Precip (mm)
50
40
30
20
10
0
Minimum Daily Relative Humidity
Rel. Hum. %
120
100
80
60
40
20
0
N D J F M A M J J A S O N D
1986
1987

Figure 5a

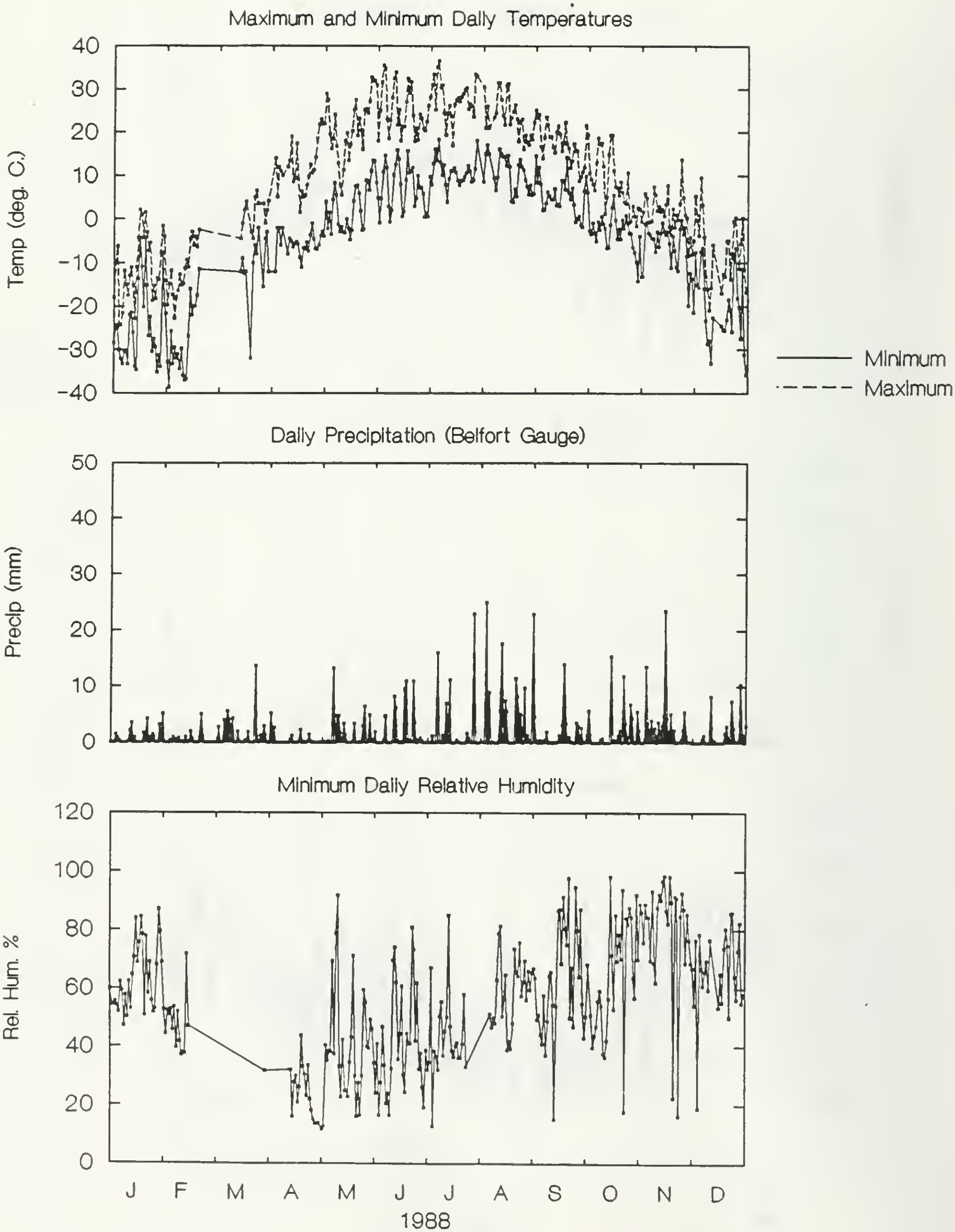
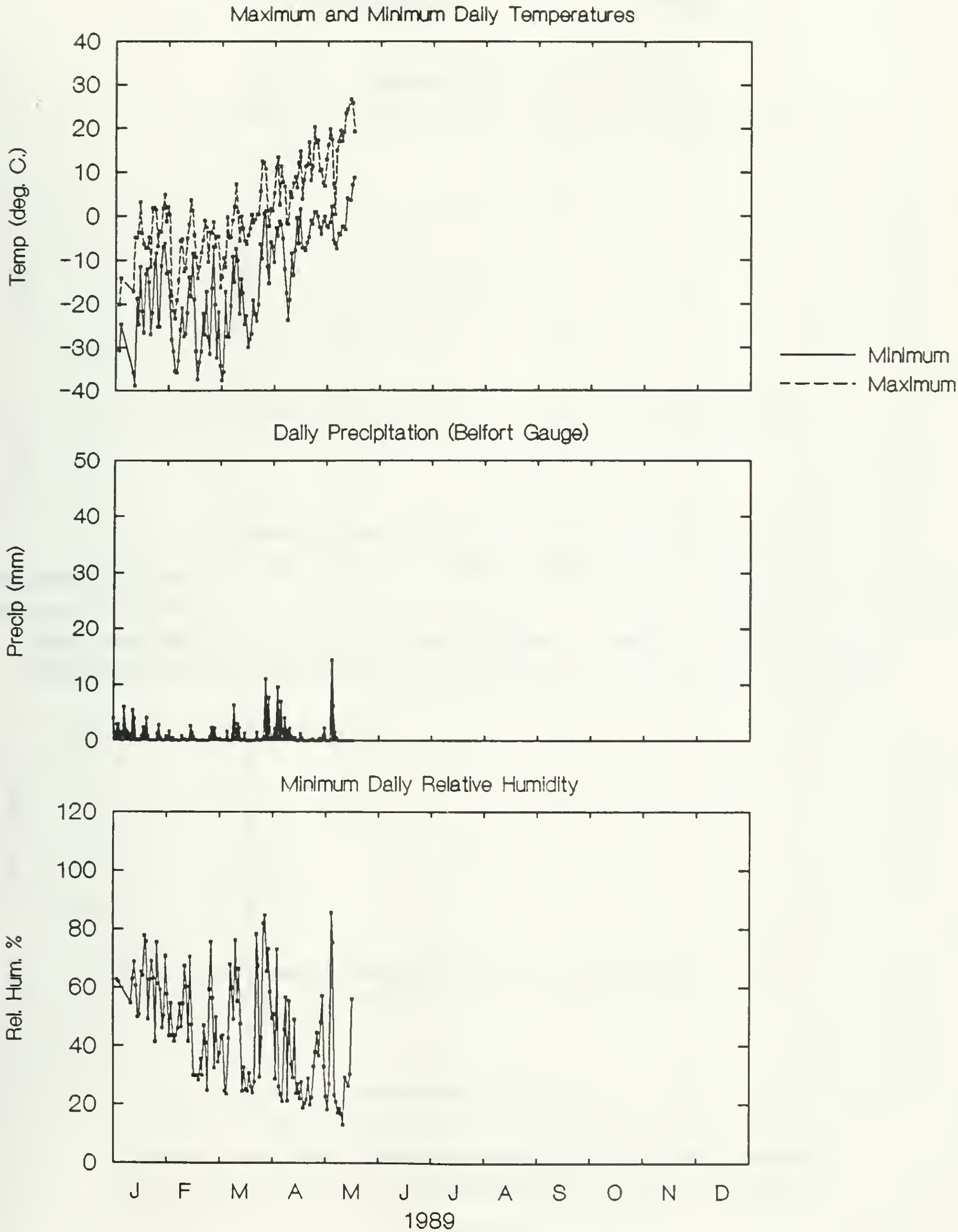

Maximum and Minimum Daily Temperatures
Temp (deg. C.)
40
30
20
10
0
-10
-20
-30
-40
Minimum
Maximum
Daily Precipitation (Belfort Gauge)
Precip (mm)
50
40
30
20
10
0
Minimum Daily Relative Humidity
Rel. Hum. %
120
100
80
60
40
20
0
J F M A M J J A S O N D
1988

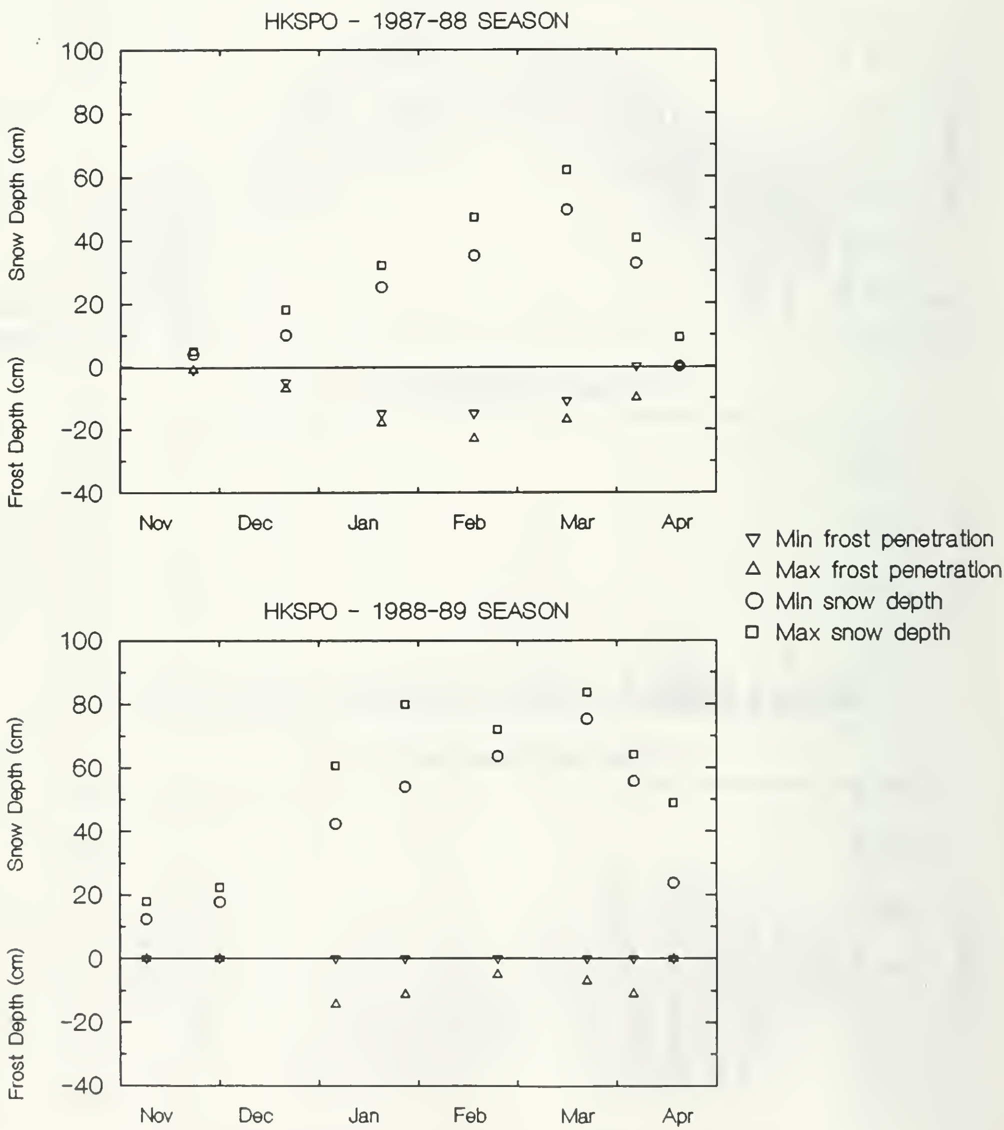
Figure 5b



Maximum and Minimum Daily Temperatures
40
30
20
10
0
-10
-20
-30
-40
Temp (deg. C.)
Minimum
Maximum
Daily Precipitation (Belfort Gauge)
50
40
30
20
10
0
Precip (mm)
Minimum Daily Relative Humidity
120
100
80
60
40
20
0
Rel. Hum. %
J F M A M J J A S O N D
1989

Figure 5c

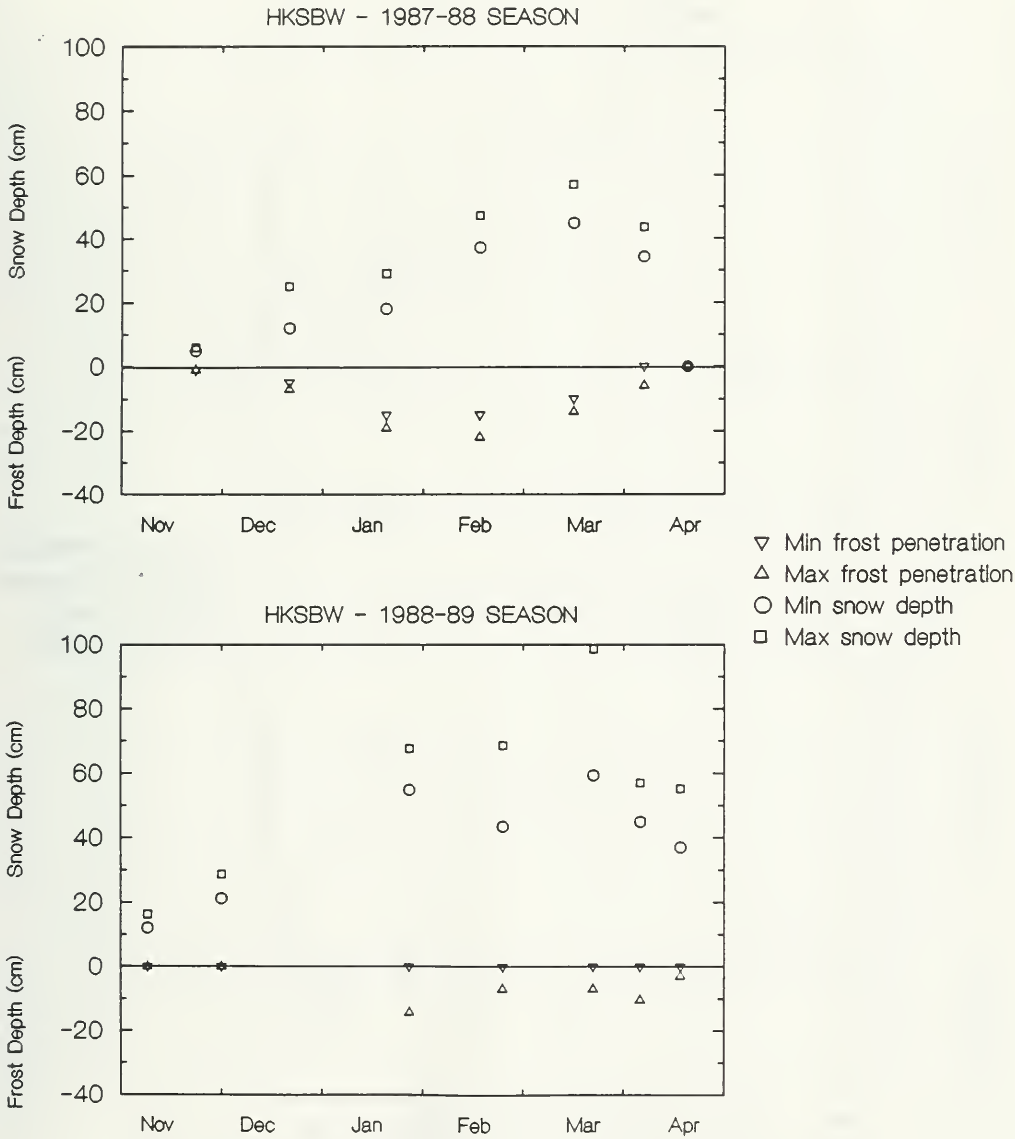
HAWKEYE LAKE FROST PENETRATION



Maximum and minimum frost penetration and snow depth from five monitoring locations within the "PO" sampling site

Figure 6a

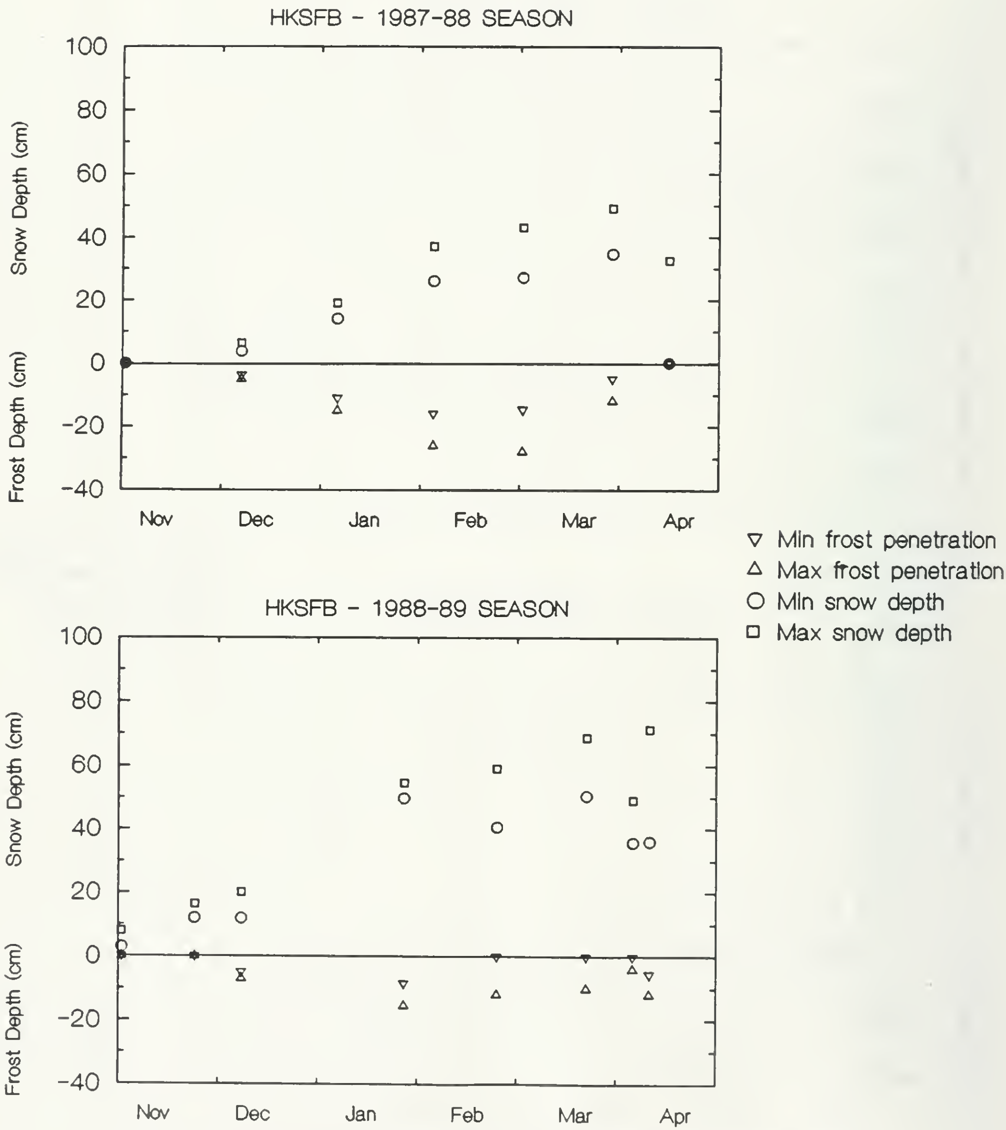
HAWKEYE LAKE FROST PENETRATION



Maximum and minimum frost penetration and snow depth from five monitoring locations within the "BW" sampling site

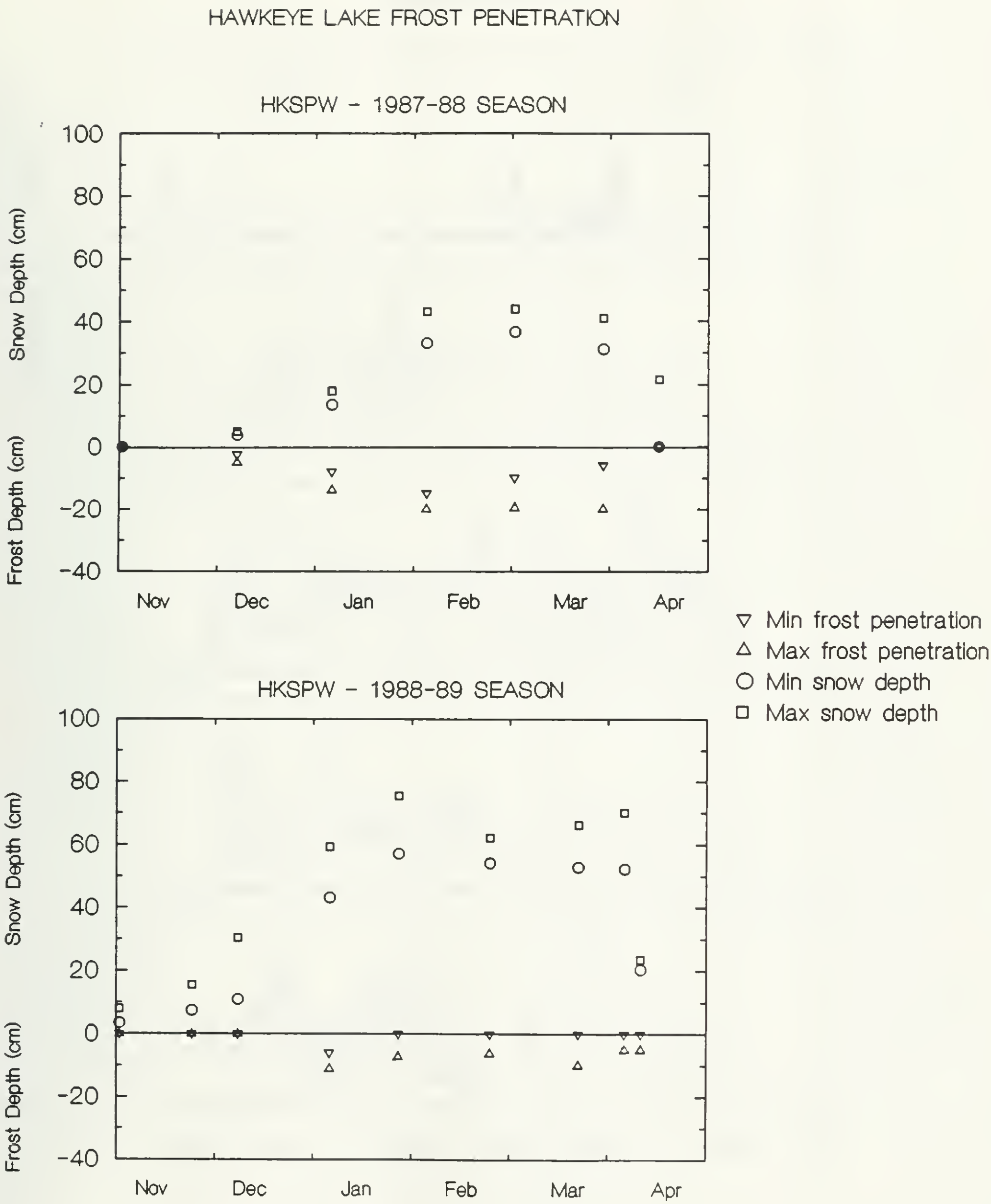
Figure 6b

HAWKEYE LAKE FROST PENETRATION



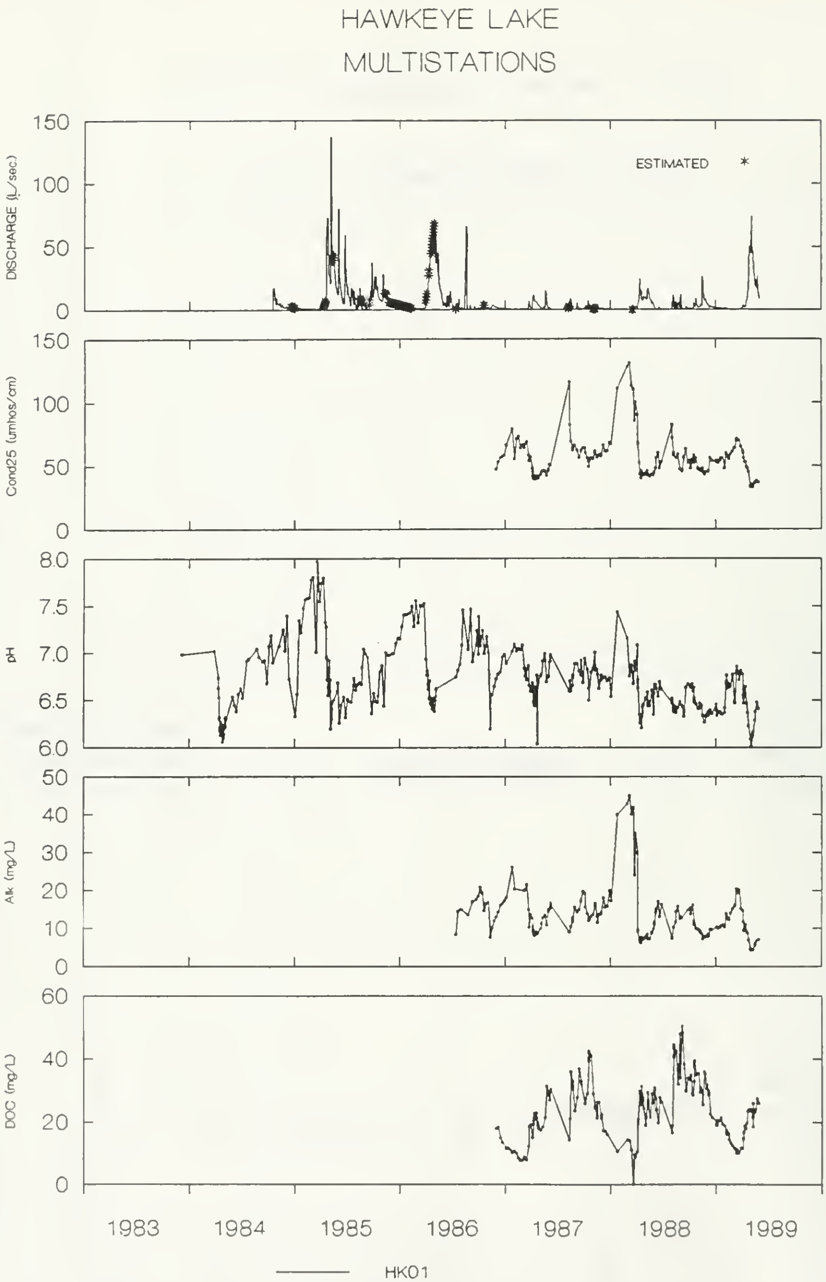
Maximum and minimum frost penetration and snow depth from five monitoring locations within the "FB" sampling site

Figure 6c



Maximum and minimum frost penetration and snow depth from five monitoring locations within the "PW" sampling site

Figure 6d



HAWKEYE LAKE
MULTISTATIONS
ESTIMATED *
DISCHARGE (L/sec)
150
100
50
0
Cond25 (umhos/cm)
150
100
50
0
pH
8.0
7.5
7.0
6.5
6.0
Alk (mg/L)
50
40
30
20
10
0
DOC (mg/L)
60
40
20
0
1983
1984
1985
1986
1987
1988
1989
HK01

Figure 7a

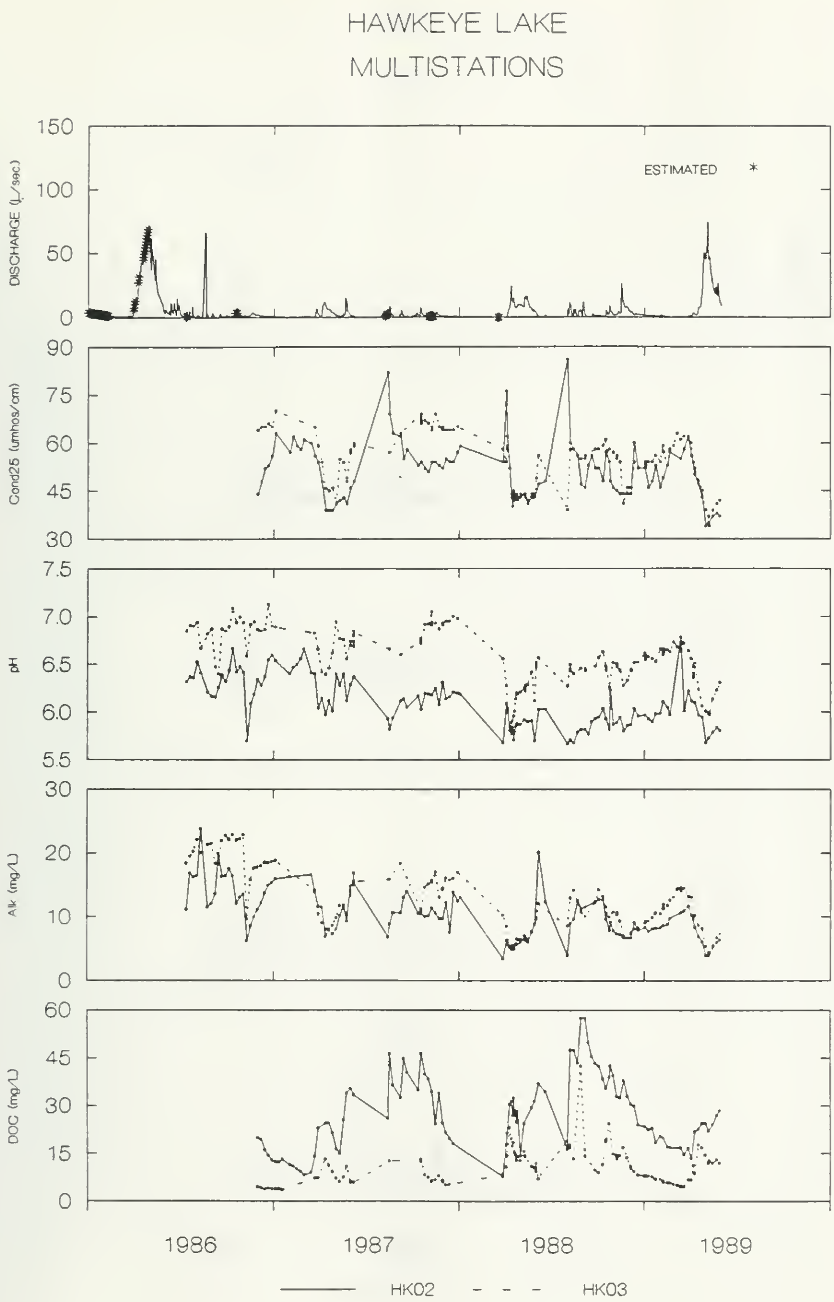


Figure 7a continued

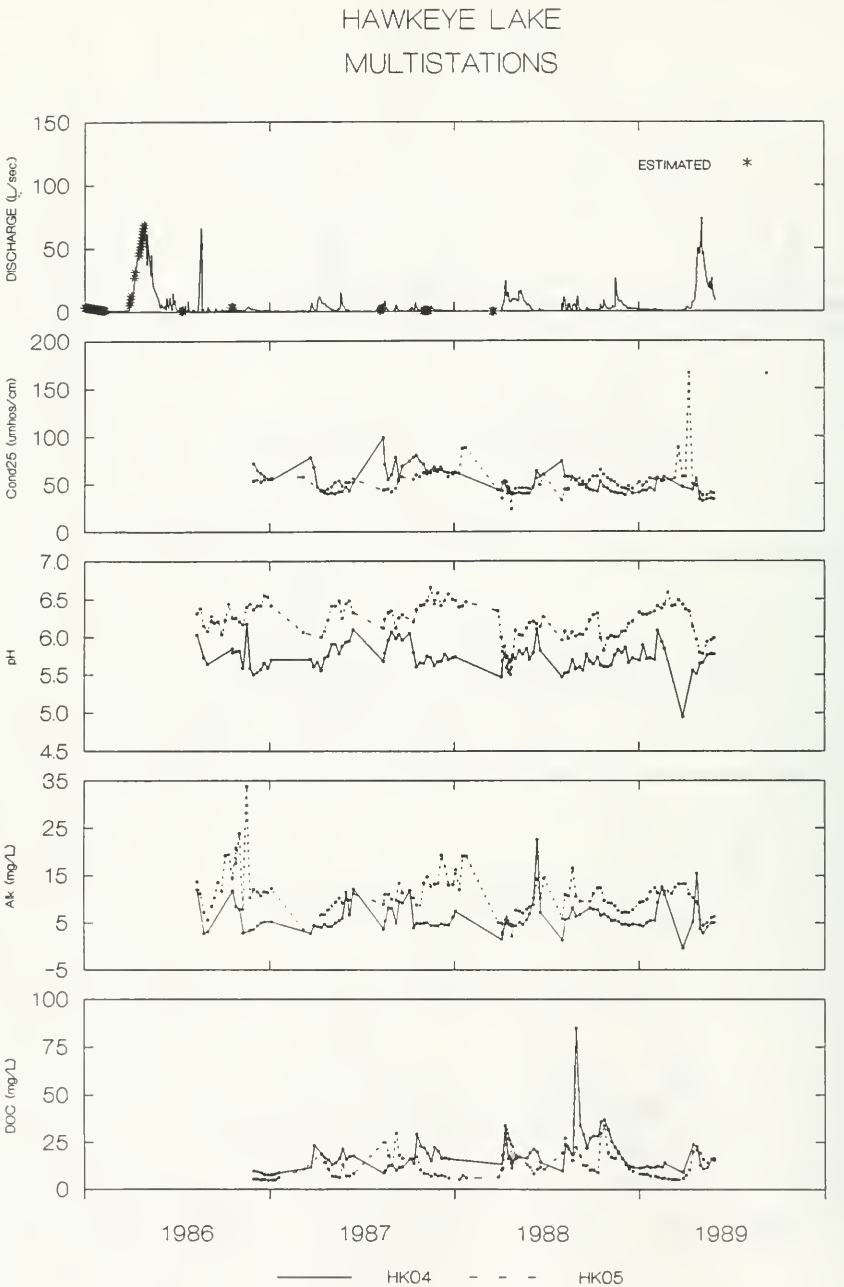


Figure 7a continued

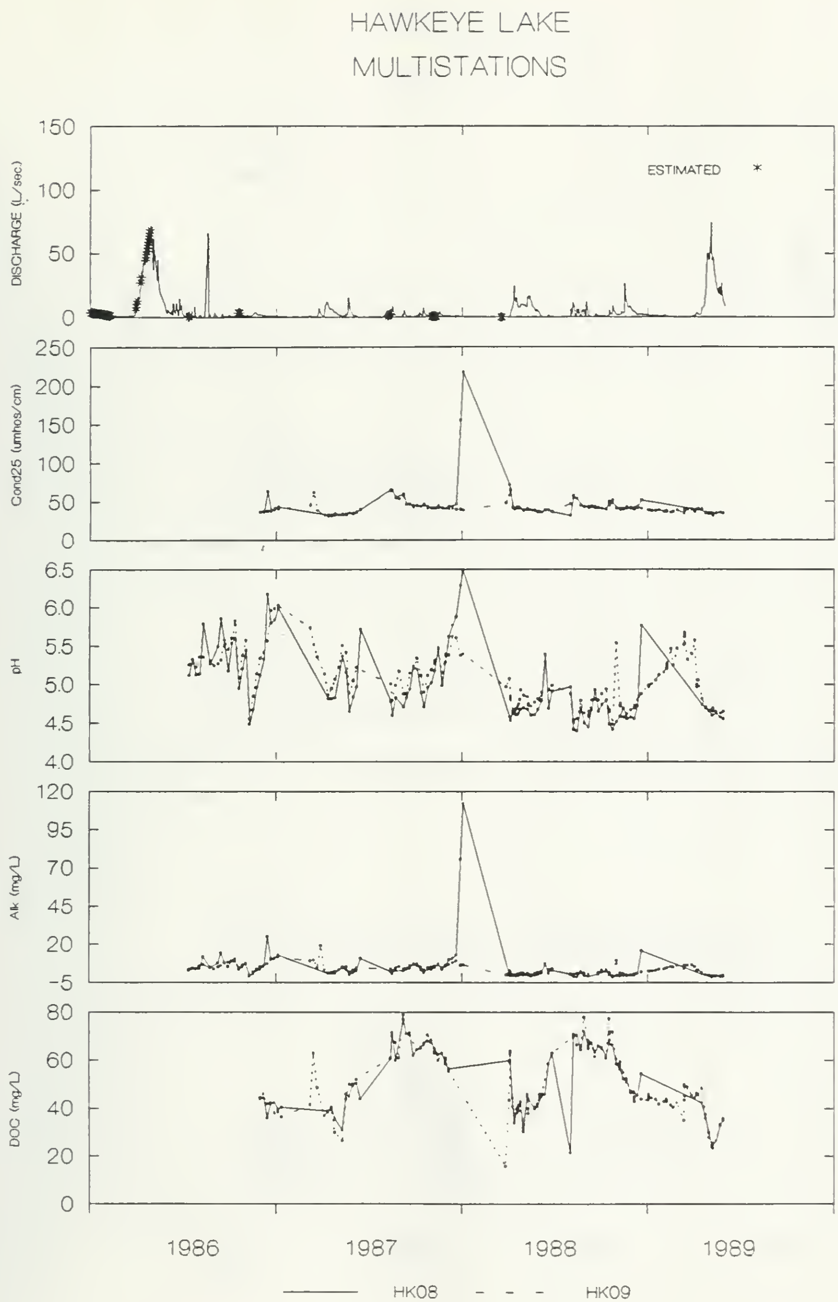


Figure 7a continued

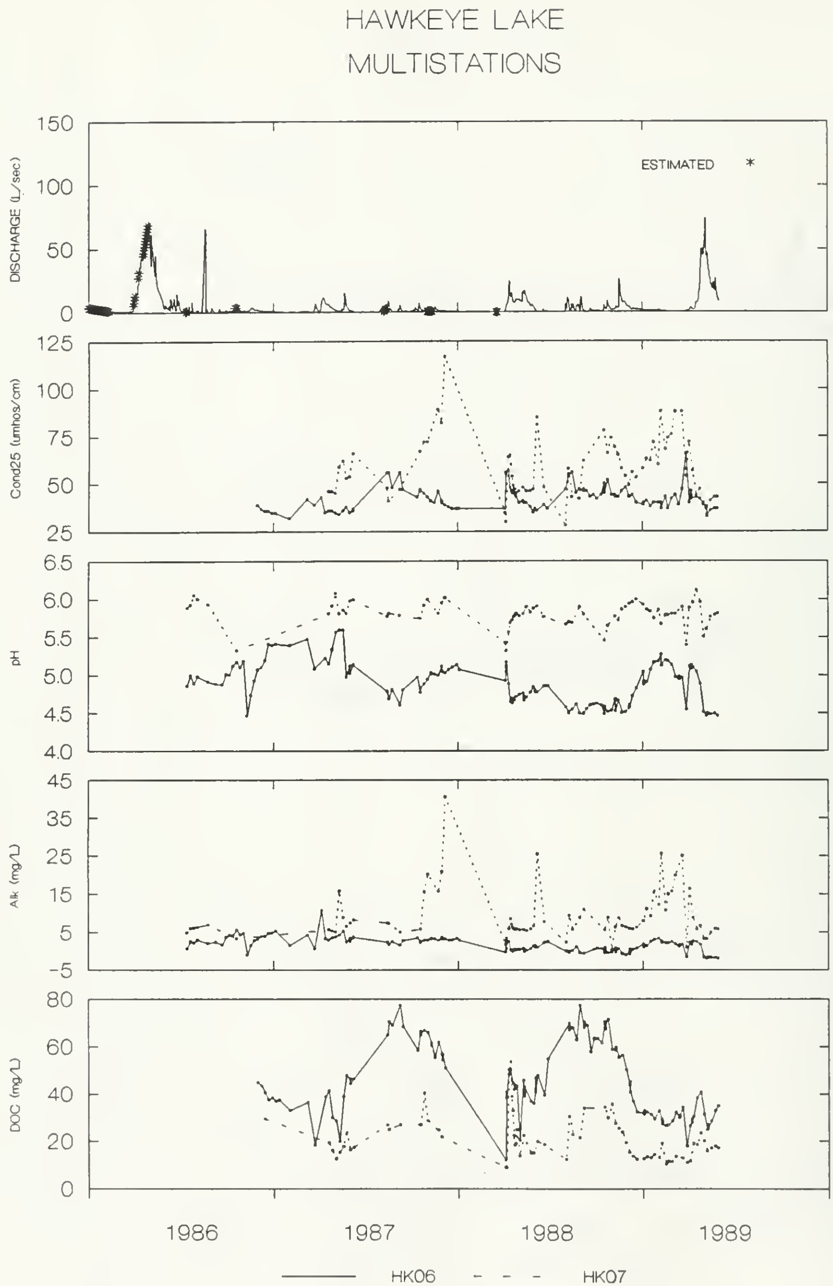


Figure 7a continued

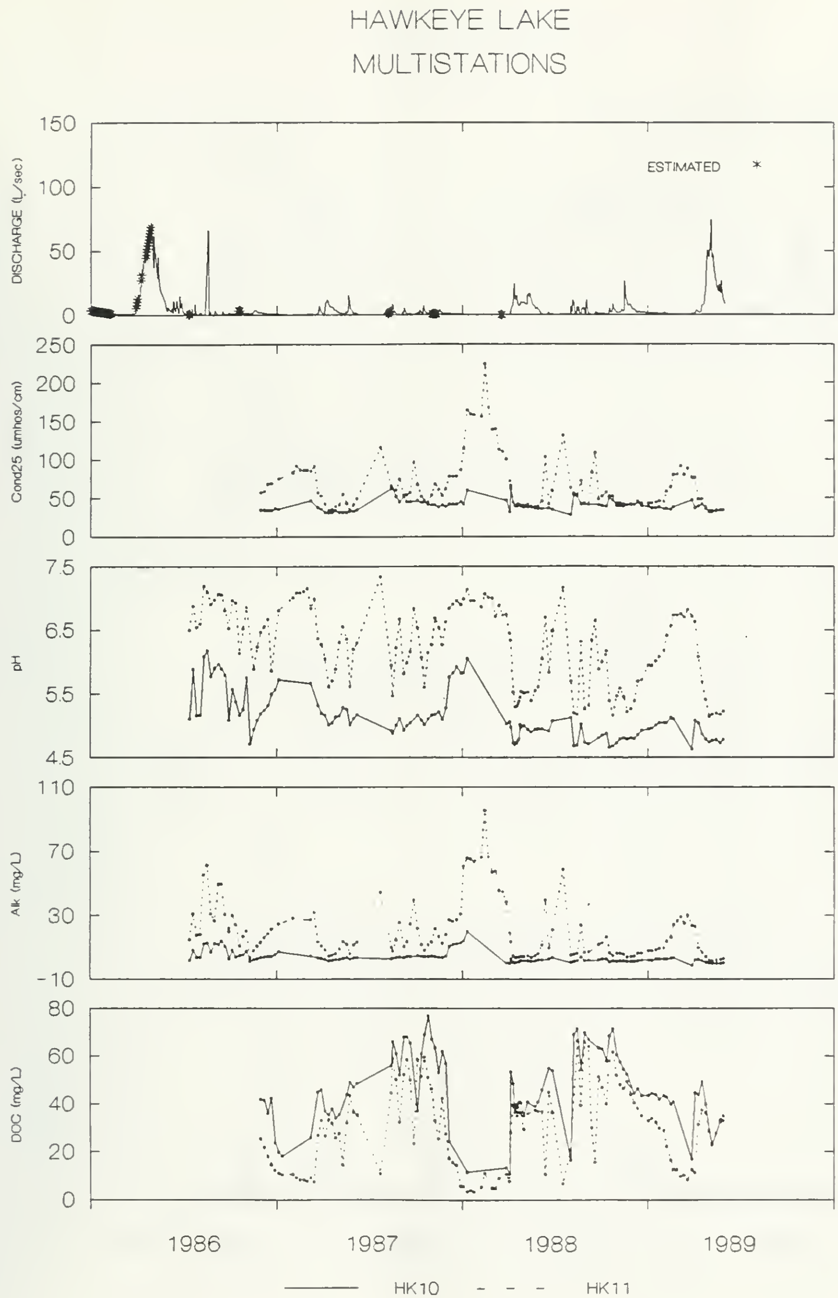


Figure 7a continued

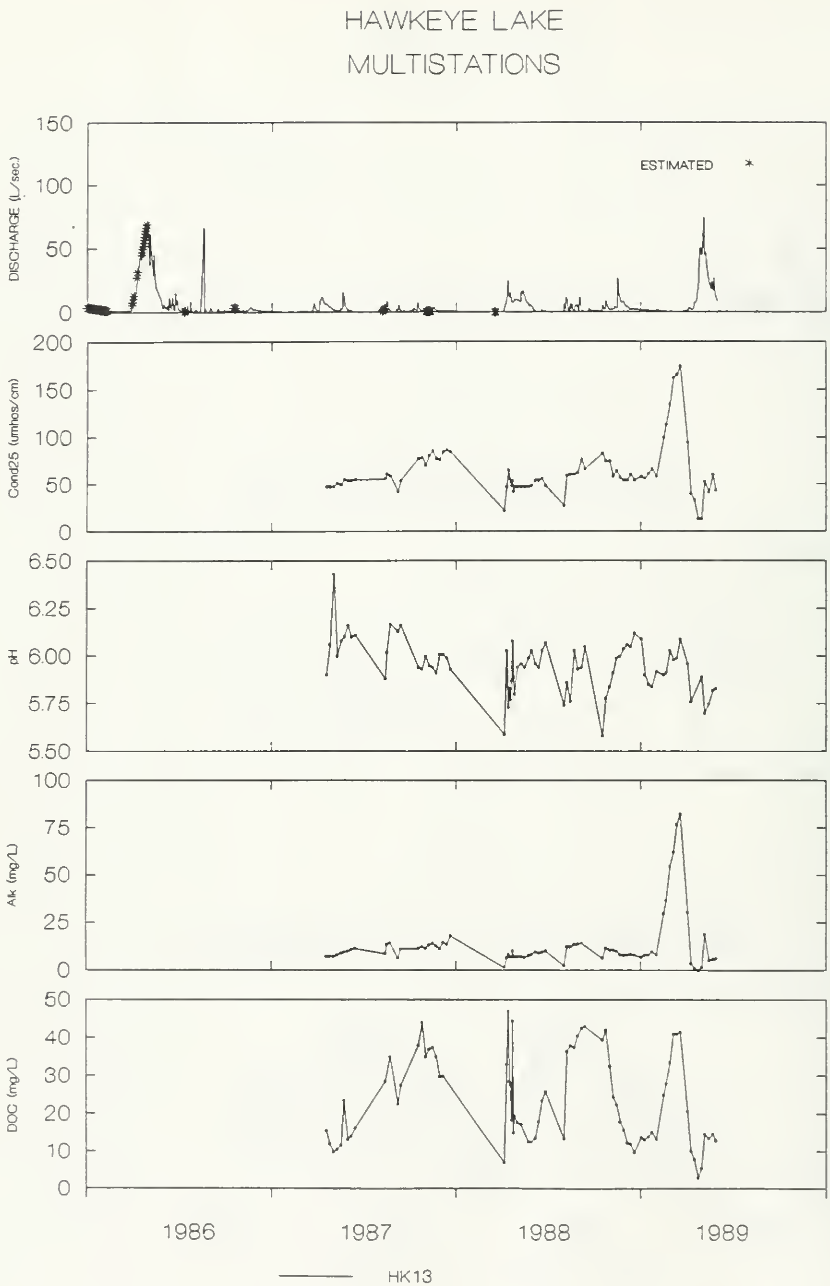
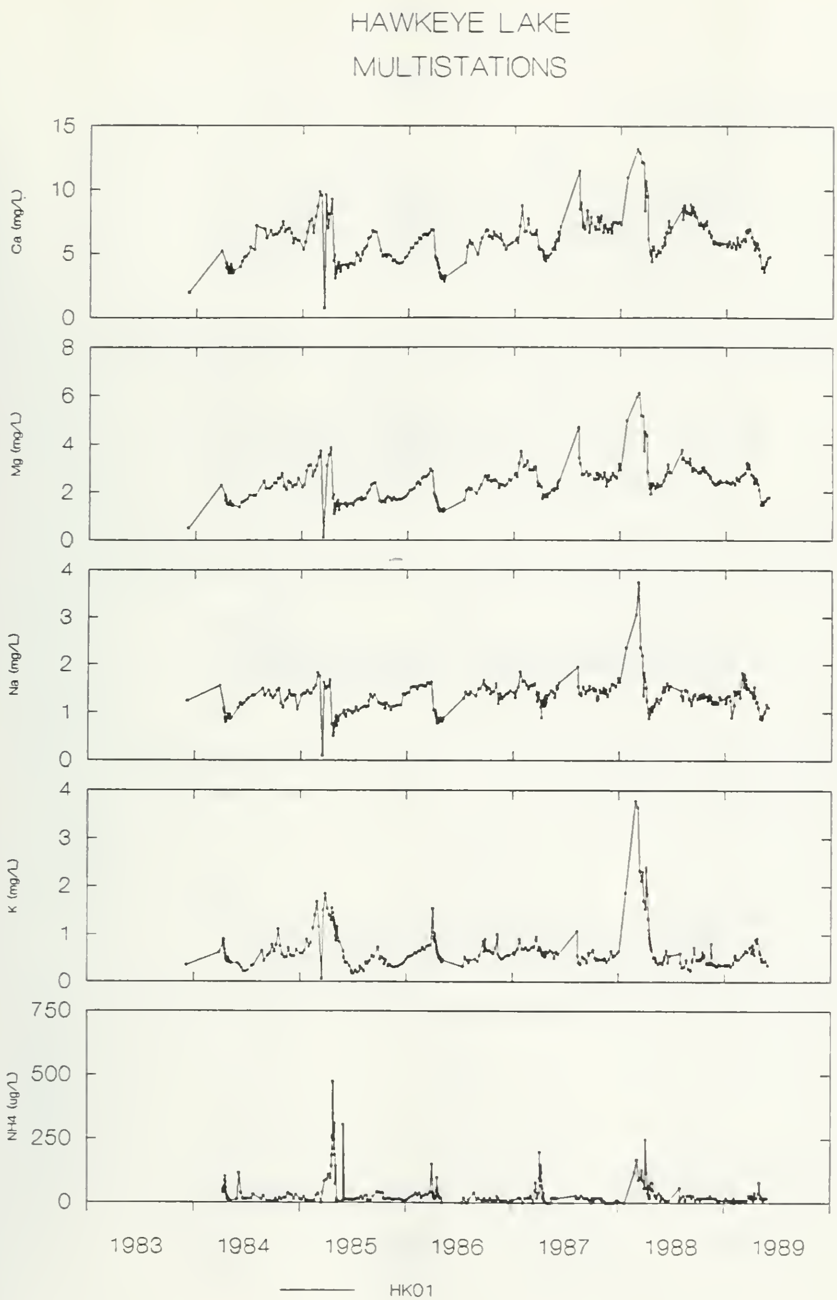


Figure 7a continued



HAWKEYE LAKE
MULTISTATIONS
15
10
5
0
Ca (mg/L)
8
6
4
2
0
Mg (mg/L)
4
3
2
1
0
Na (mg/L)
4
3
2
1
0
K (mg/L)
750
500
250
0
NH4 (ug/L)
1983
1984
1985
1986
1987
1988
1989
HK01

Figure 7b

HAWKEYE LAKE
MULTISTATIONS

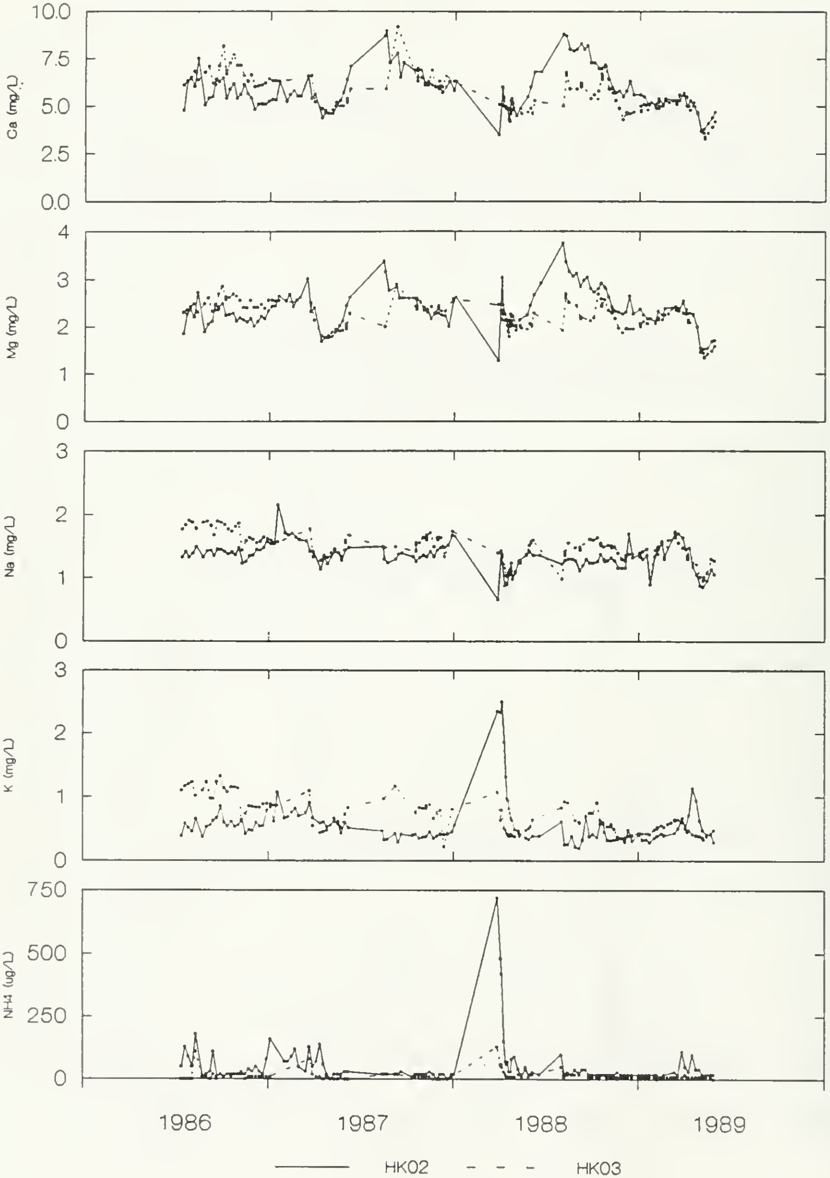


Figure 7b continued

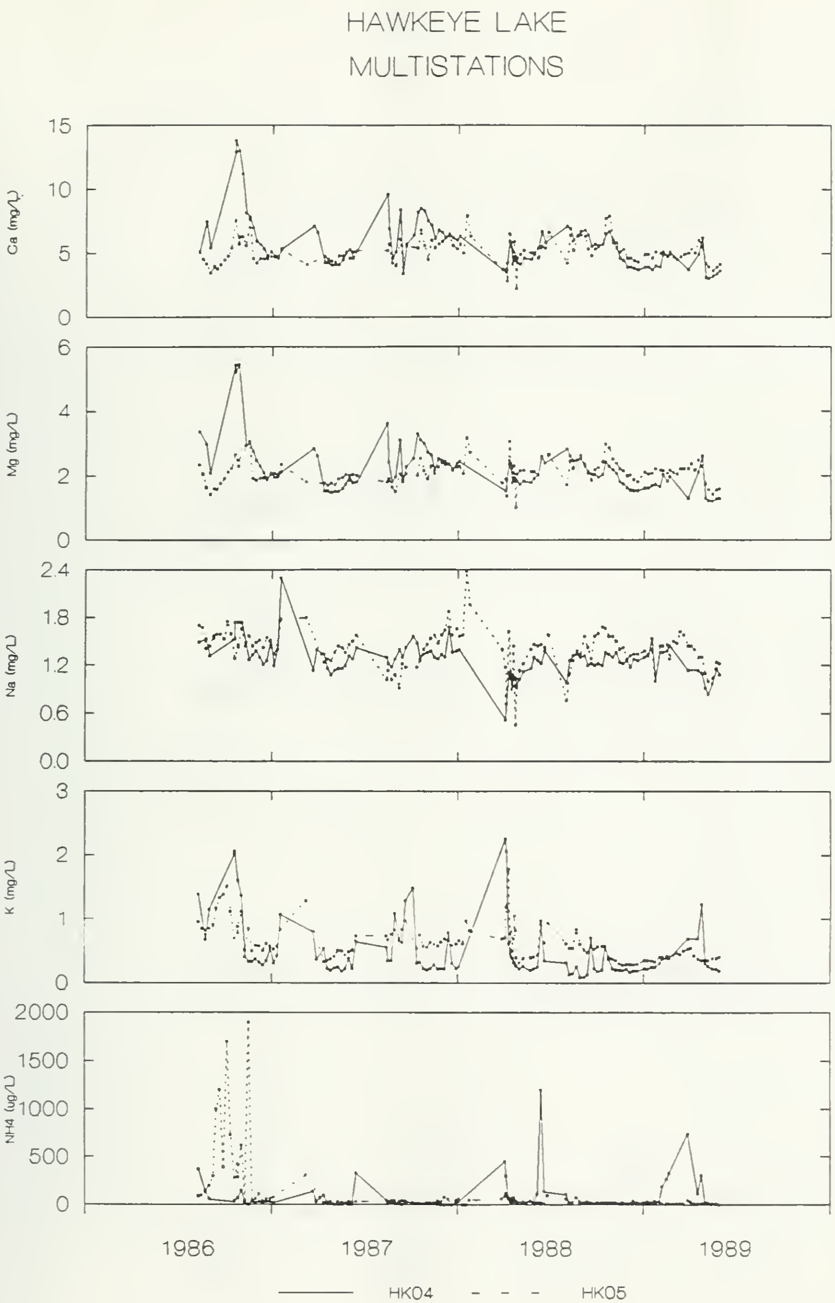


Figure 7b continued

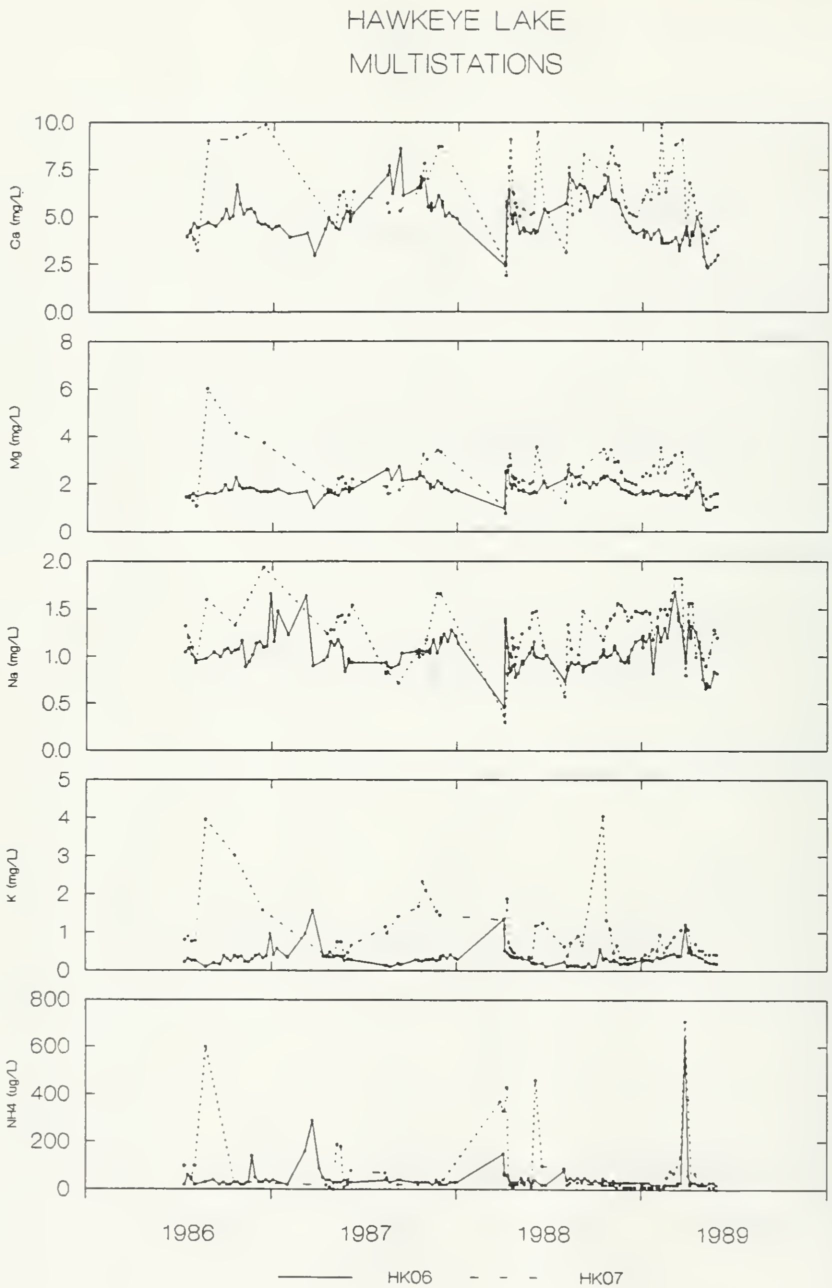


Figure 7b continued

HAWKEYE LAKE
MULTISTATIONS

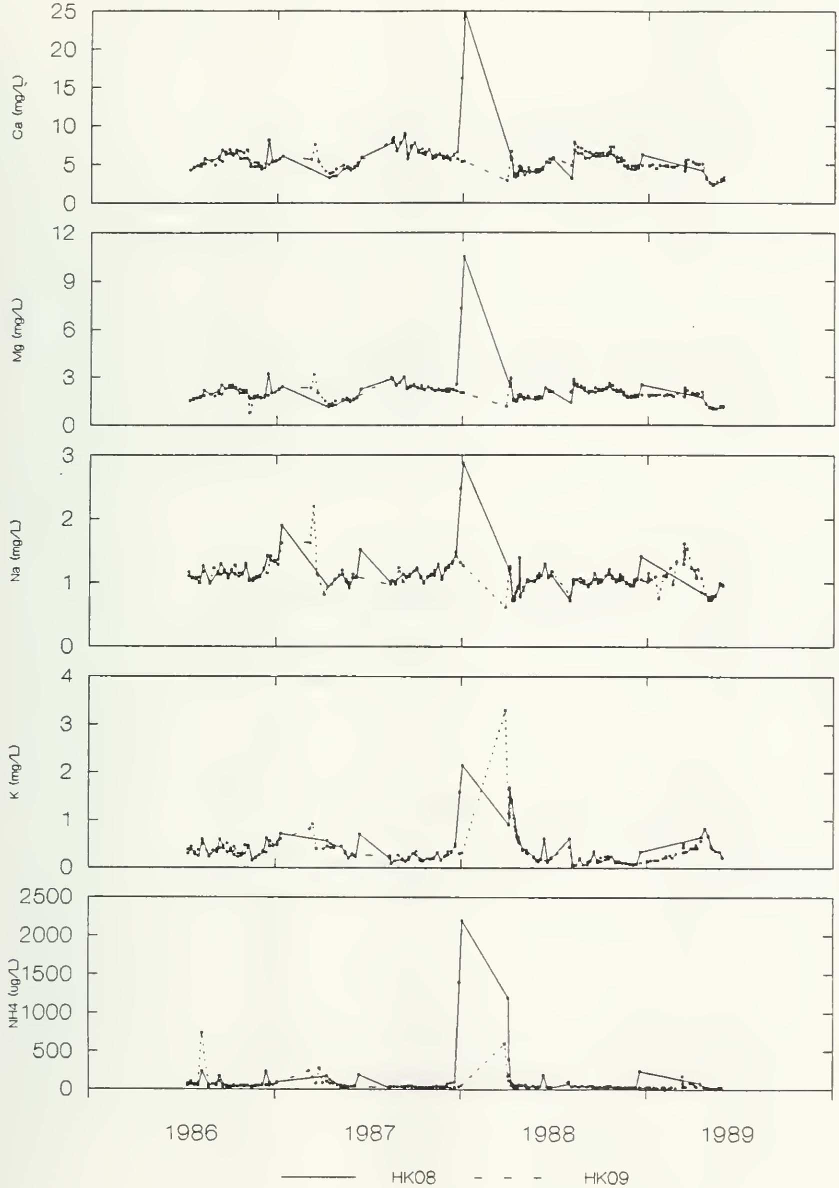


Figure 7b continued

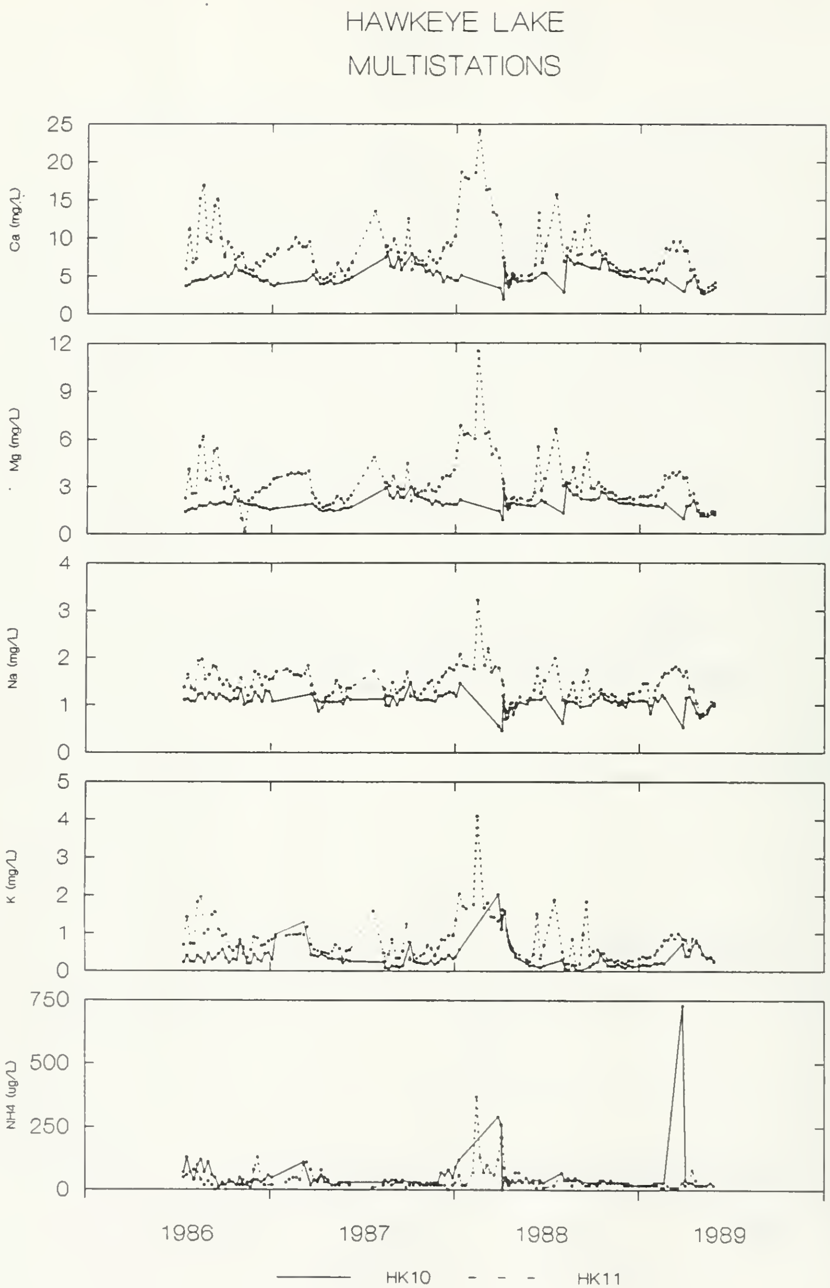


Figure 7b continued

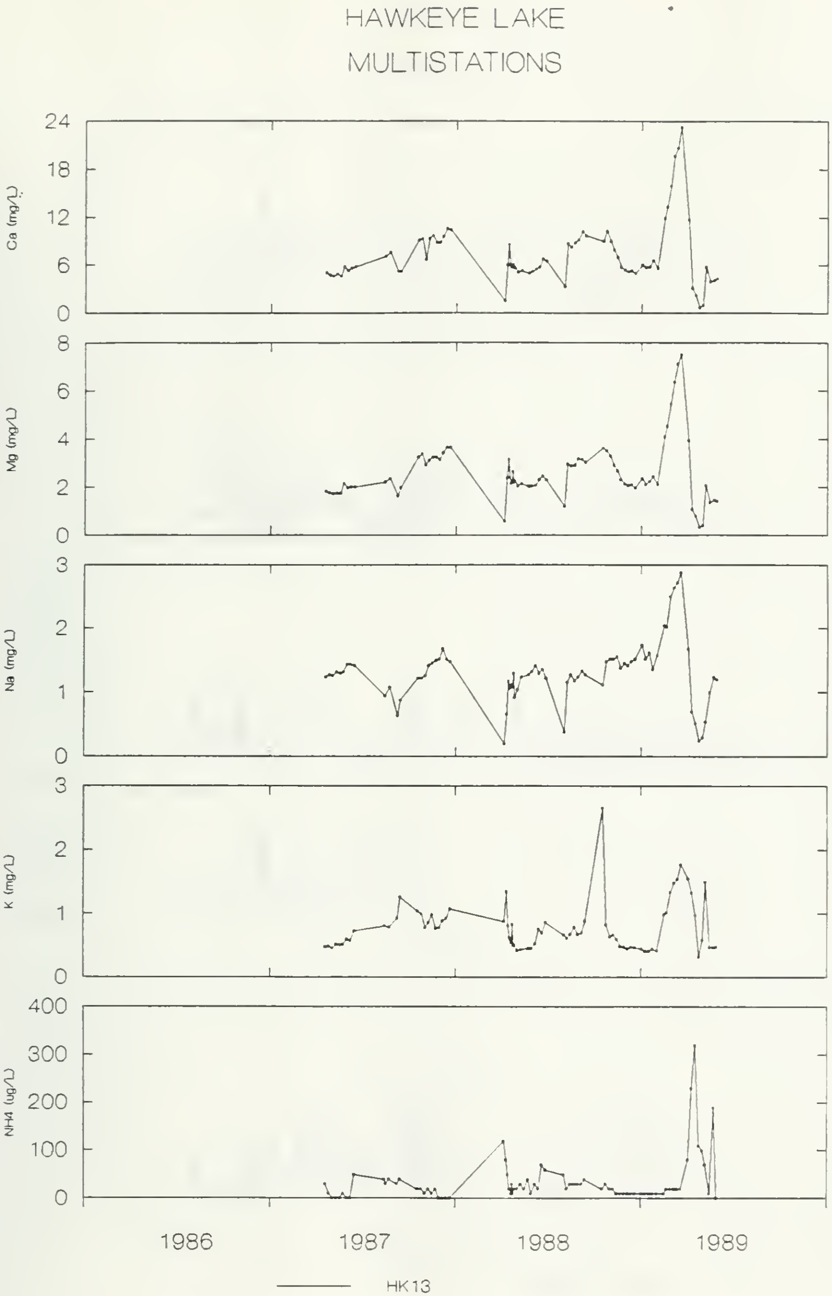


Figure 7b continued

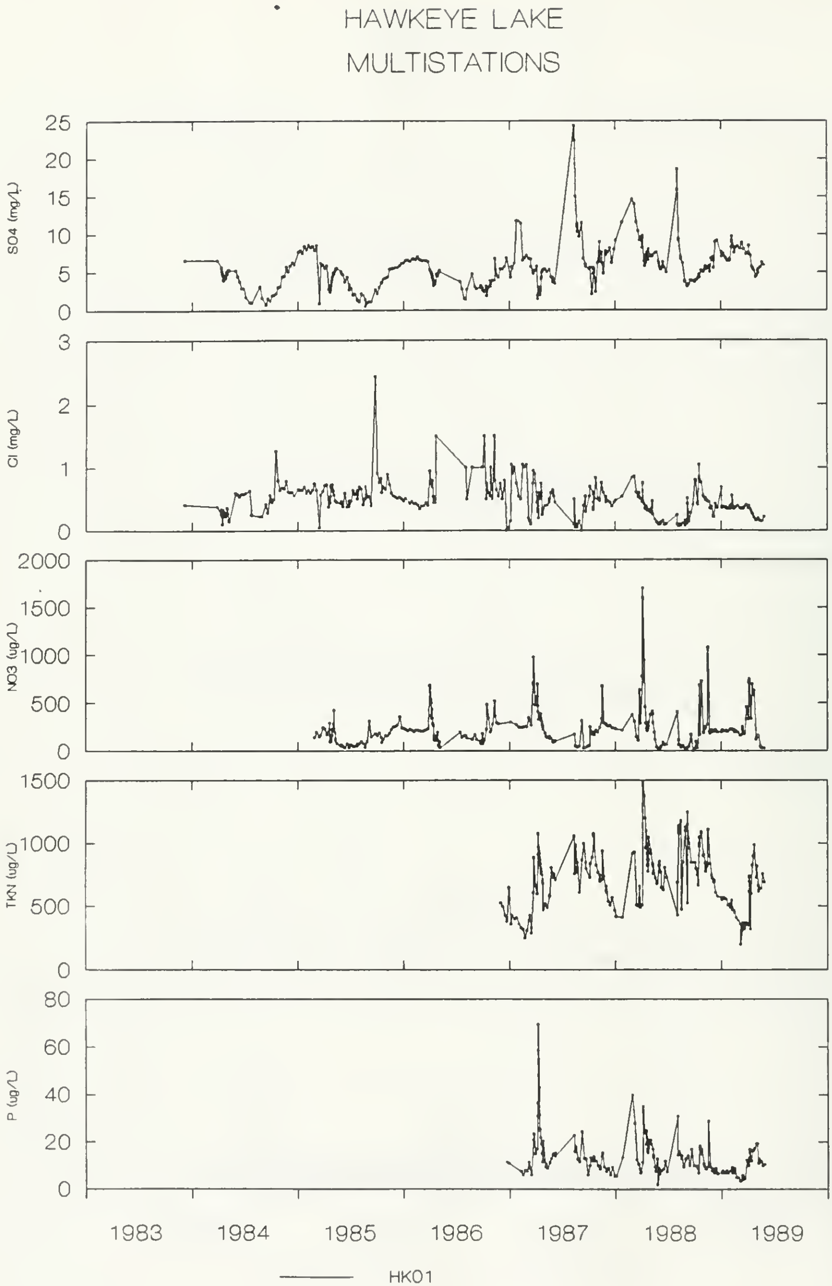

HAWKEYE LAKE
MULTISTATIONS
SO4 (mg/L)
Cl (mg/L)
NO3 (ug/L)
TKN (ug/L)
P (ug/L)
1983
1984
1985
1986
1987
1988
1989
HK01

Figure 7c

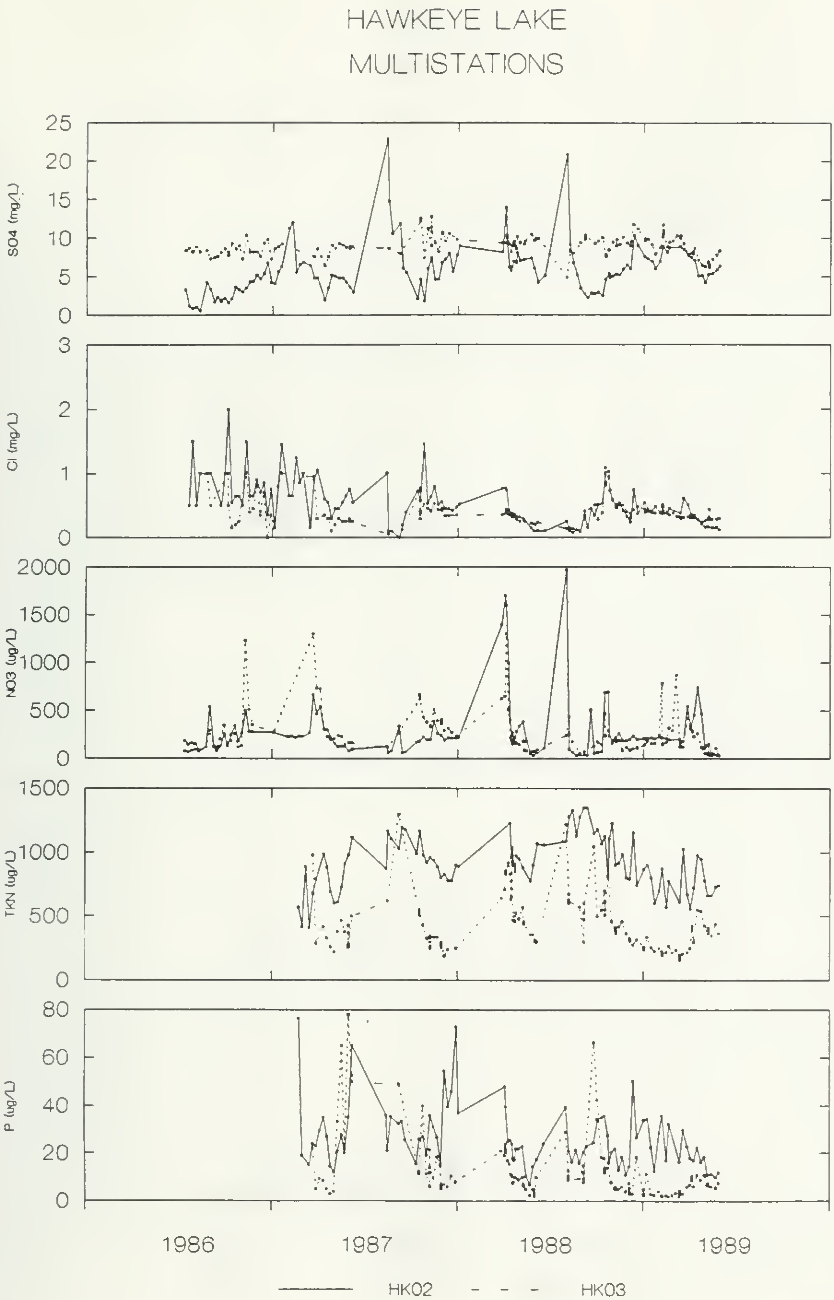


Figure 7c continued

HAWKEYE LAKE
MULTISTATIONS

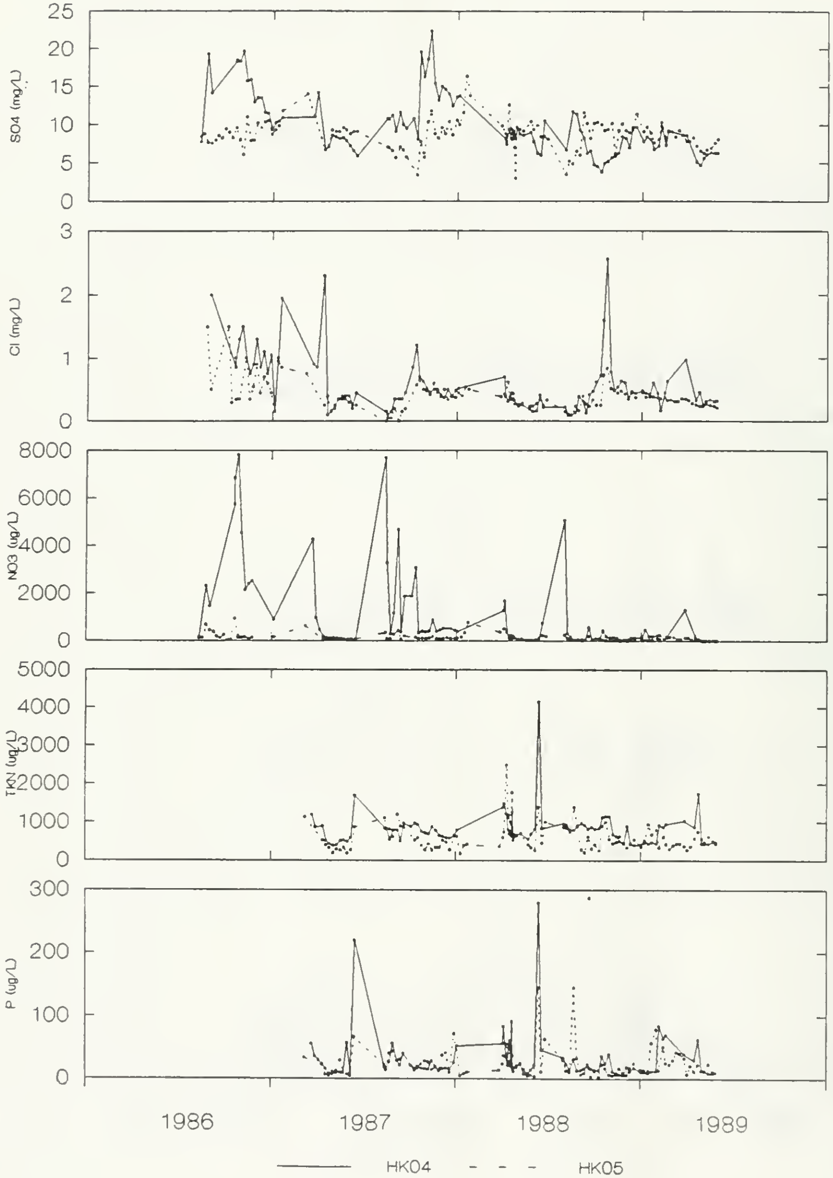


Figure 7c continued

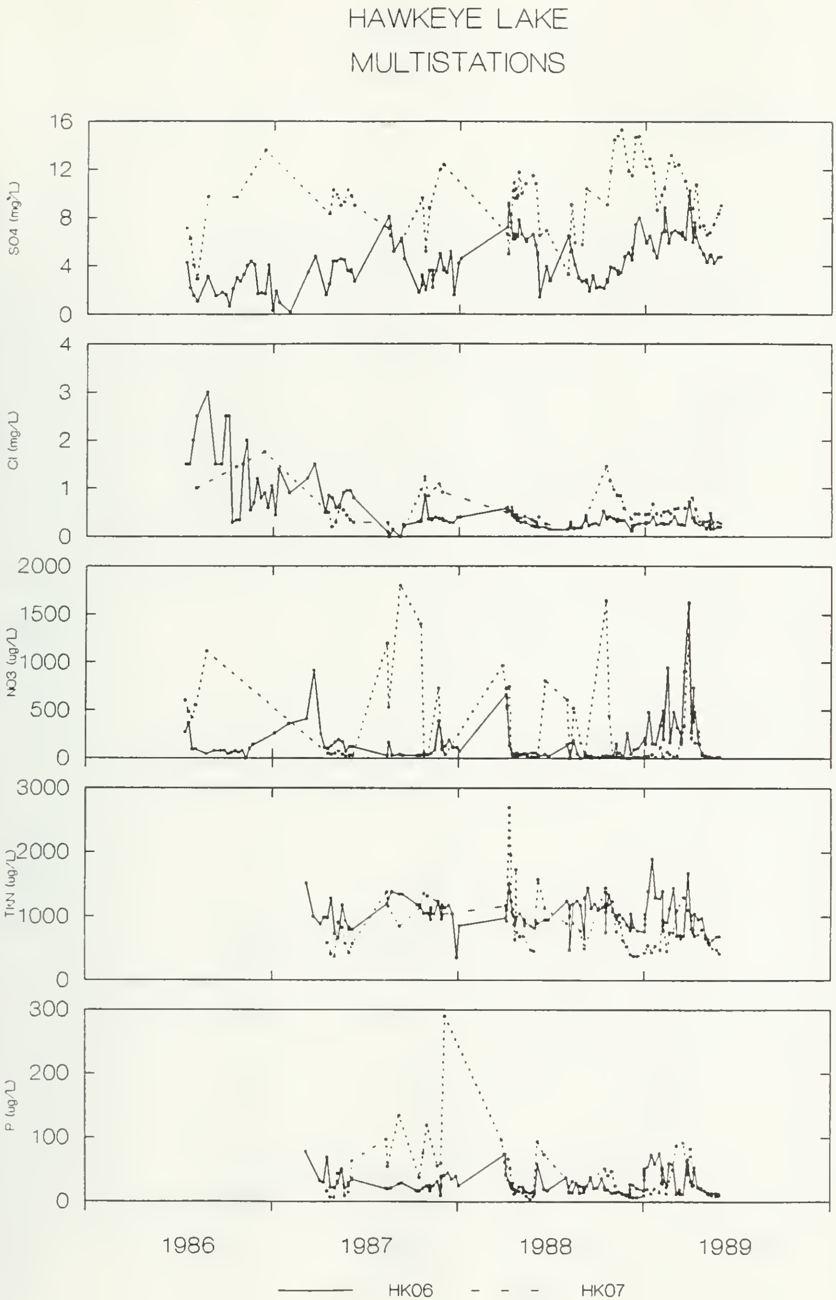


Figure 7c continued

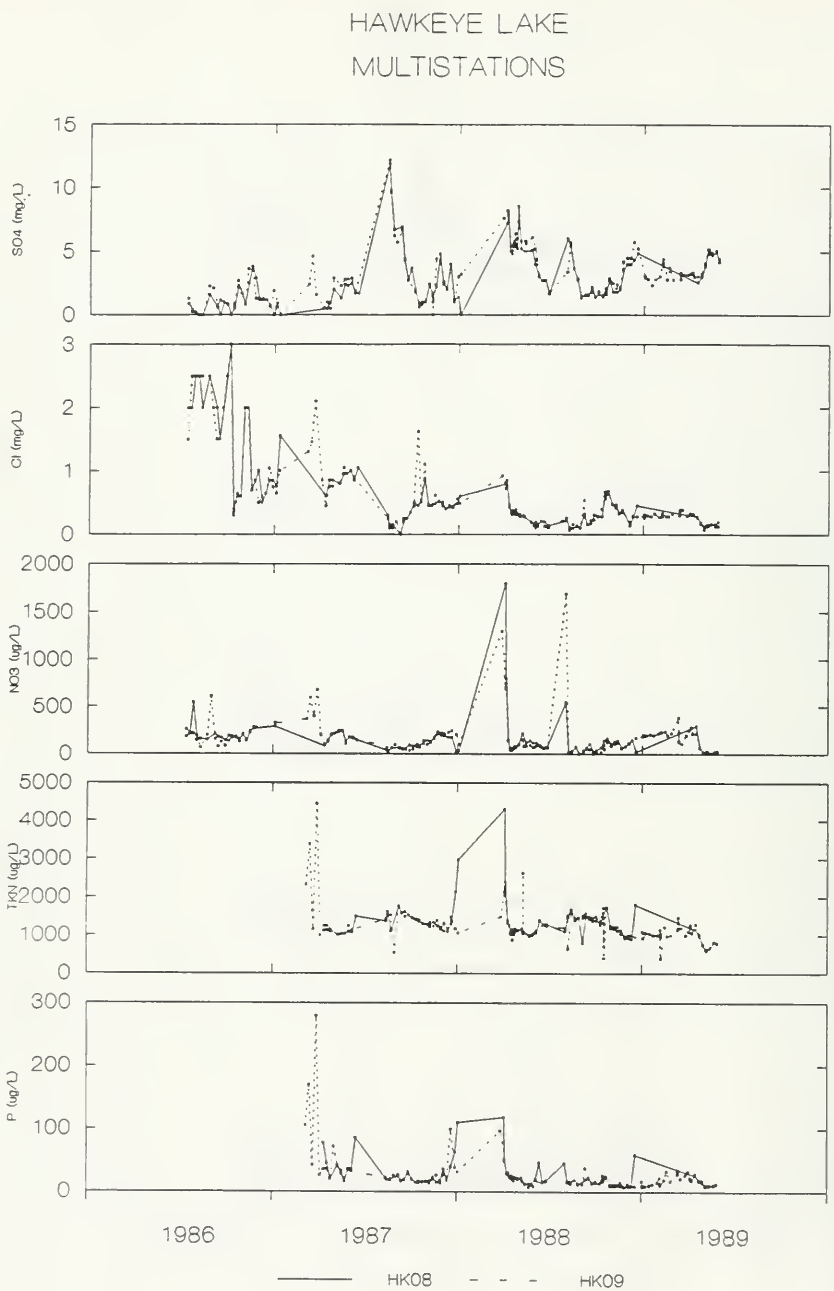


Figure 7c continued

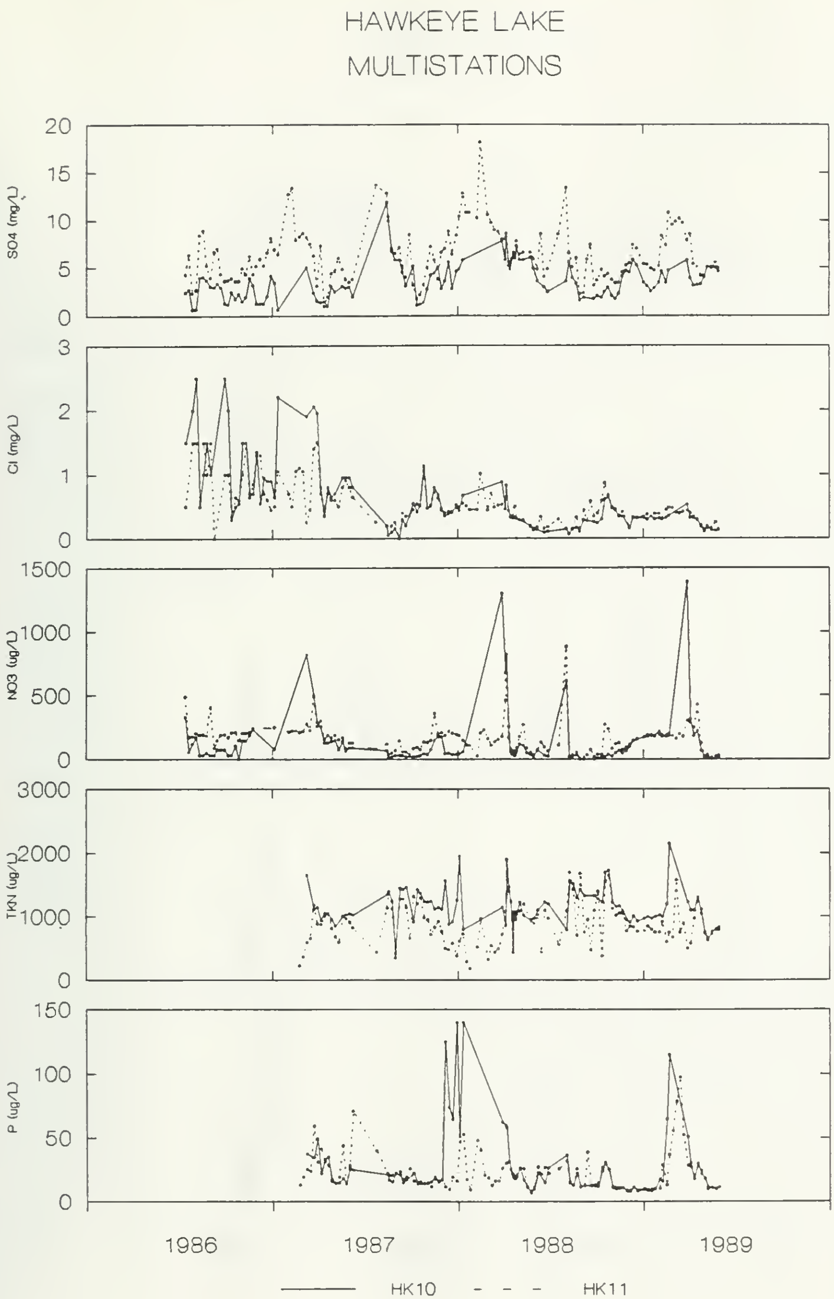


Figure 7c continued

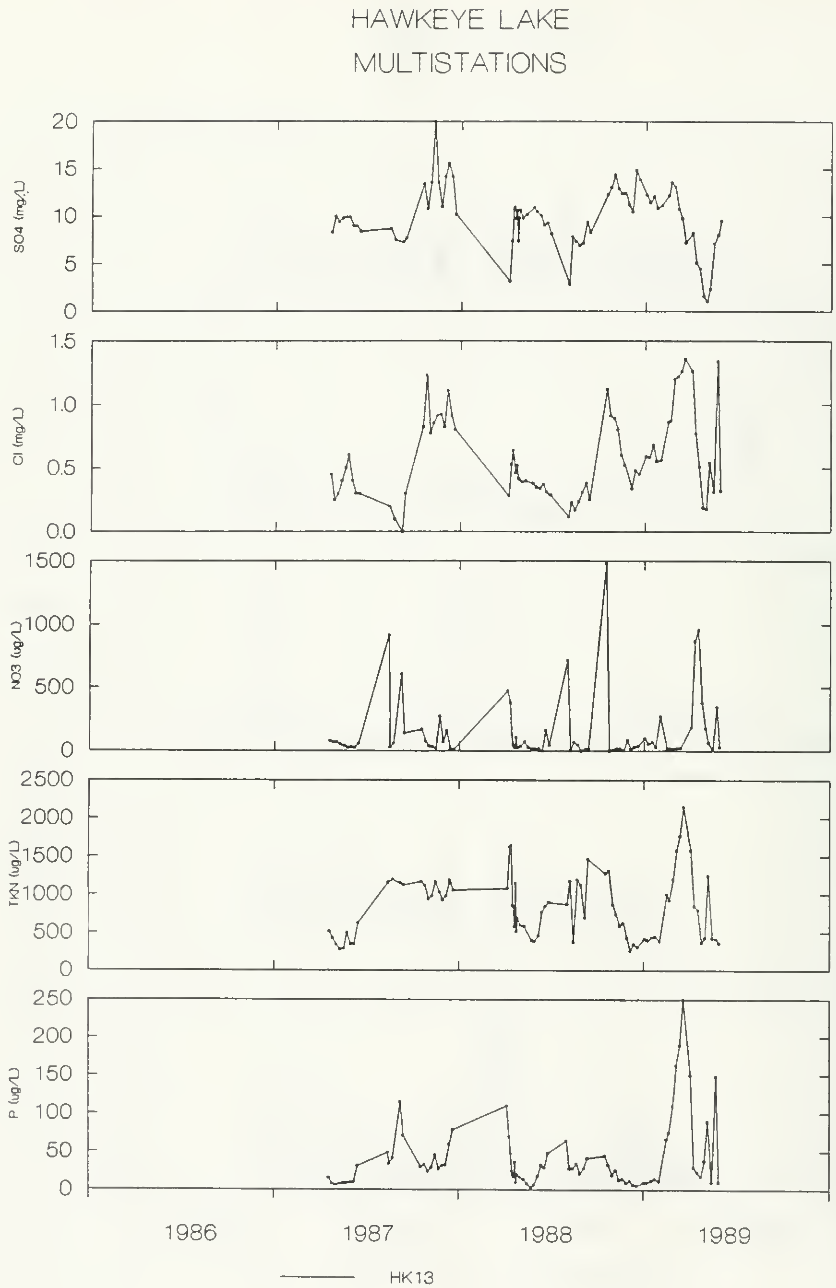
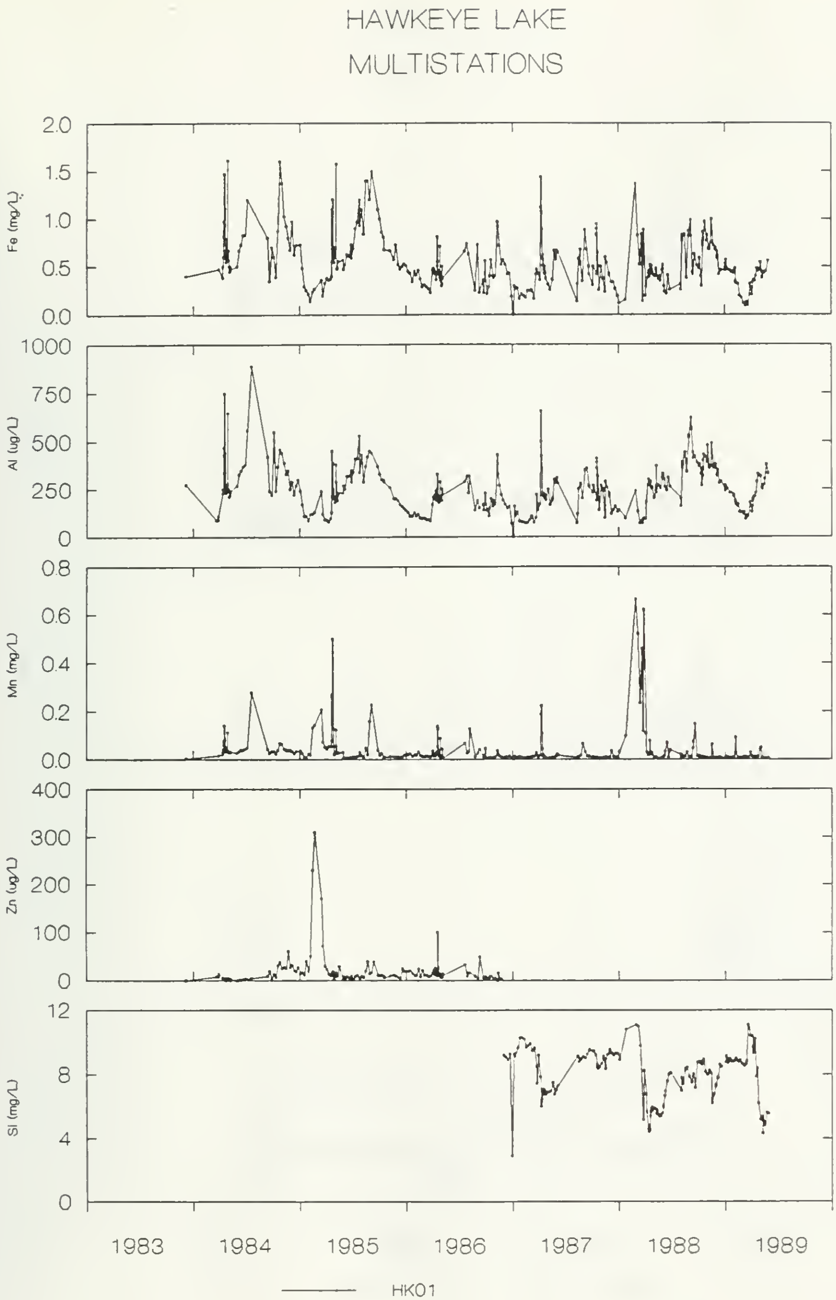


Figure 7c continued



HAWKEYE LAKE
MULTISTATIONS
Fe (mg/L)
Al (ug/L)
Mn (mg/L)
Zn (ug/L)
Si (mg/L)
2.0
1.5
1.0
0.5
0.0
1000
750
500
250
0
0.8
0.6
0.4
0.2
0.0
400
300
200
100
0
12
8
4
0
1983
1984
1985
1986
1987
1988
1989
HK01

Figure 7d

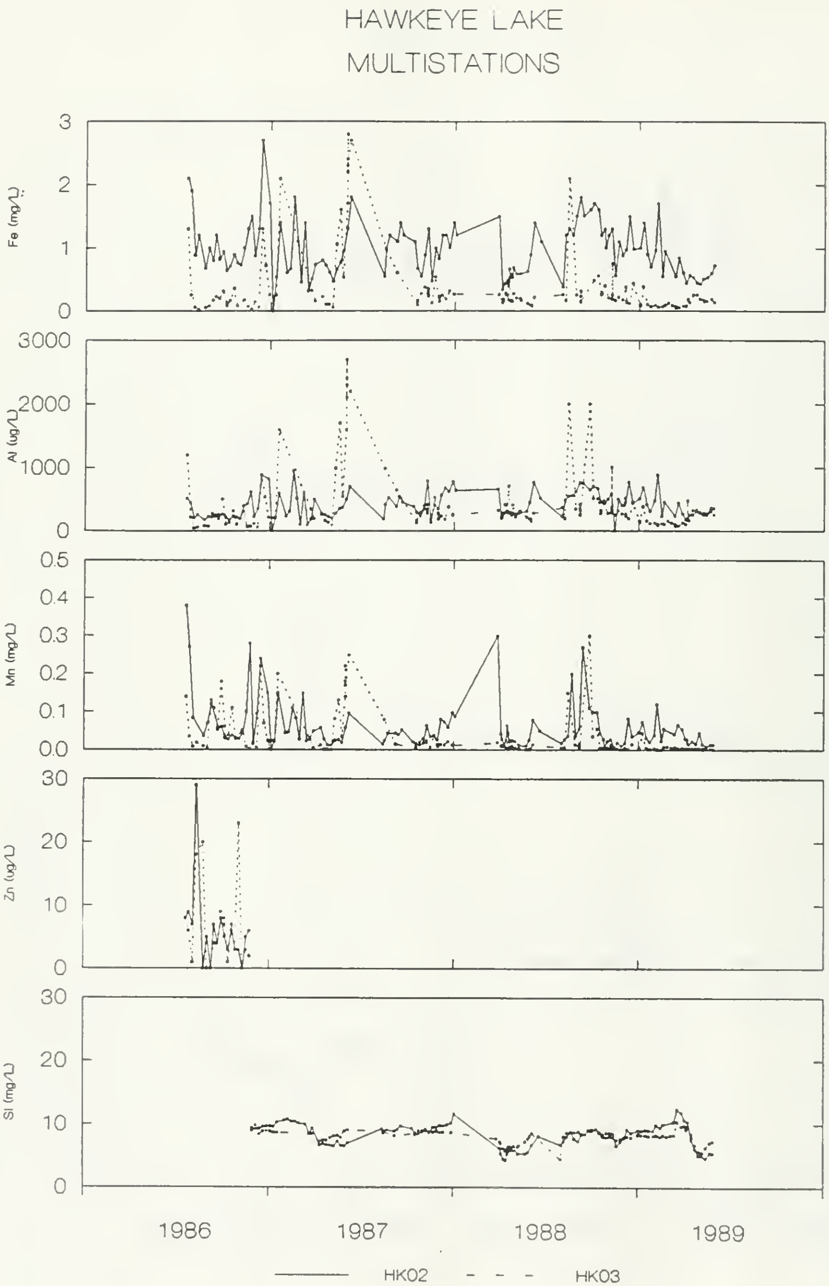


Figure 7d continued

HAWKEYE LAKE
MULTISTATIONS

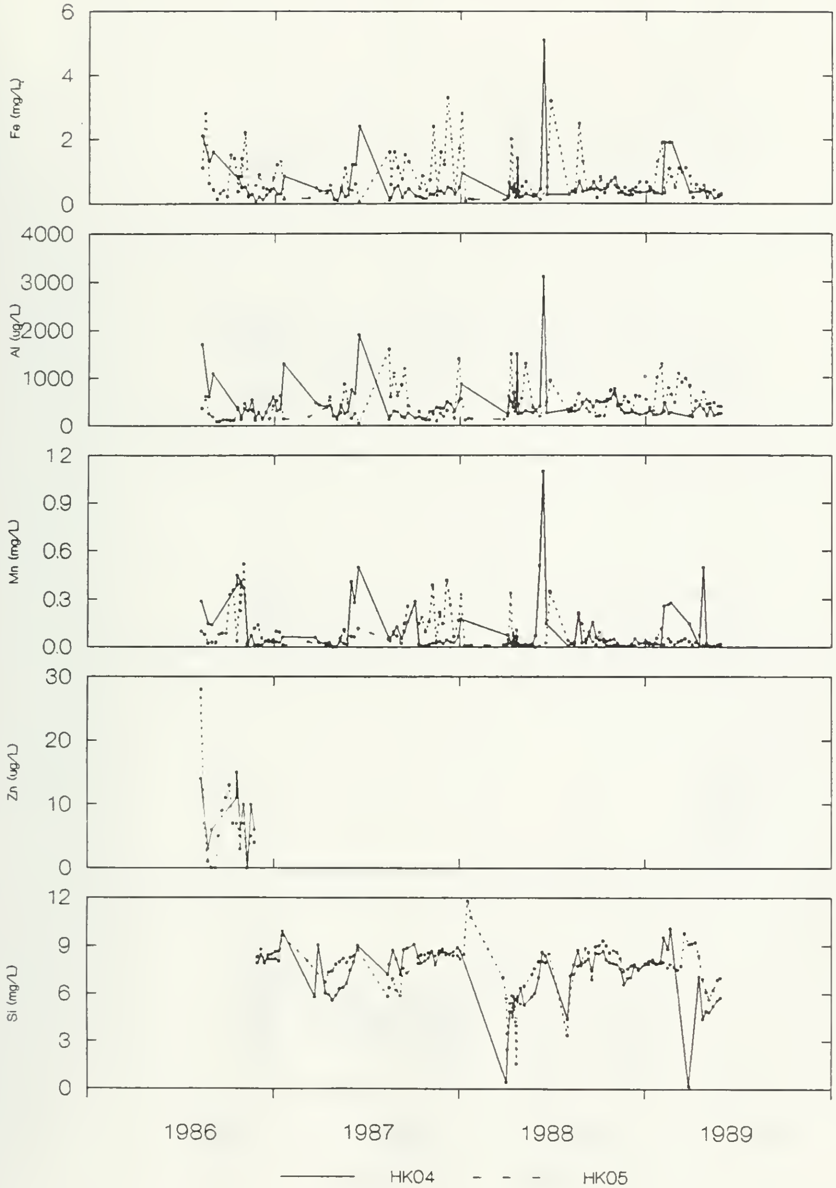


Figure 7d continued

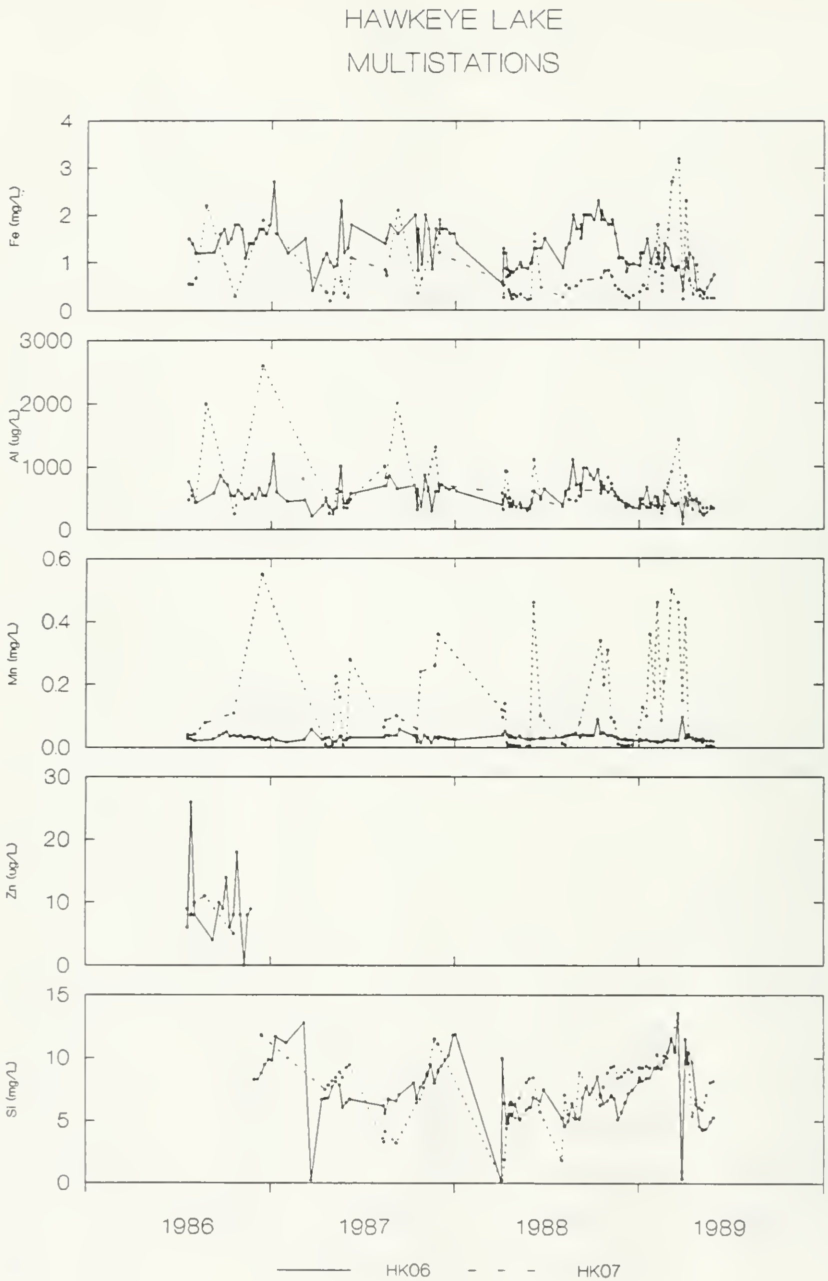


Figure 7d continued

HAWKEYE LAKE
MULTISTATIONS

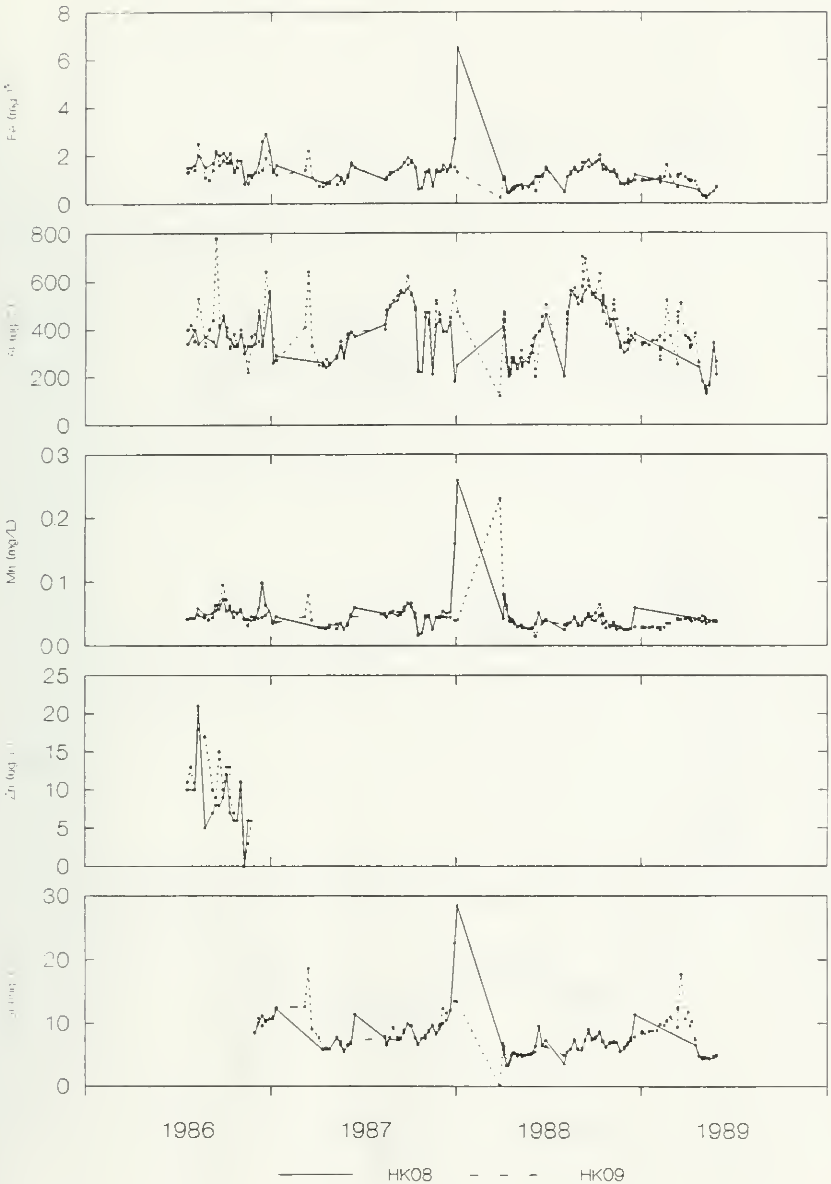


Figure 7d continued

HAWKEYE LAKE
MULTISTATIONS

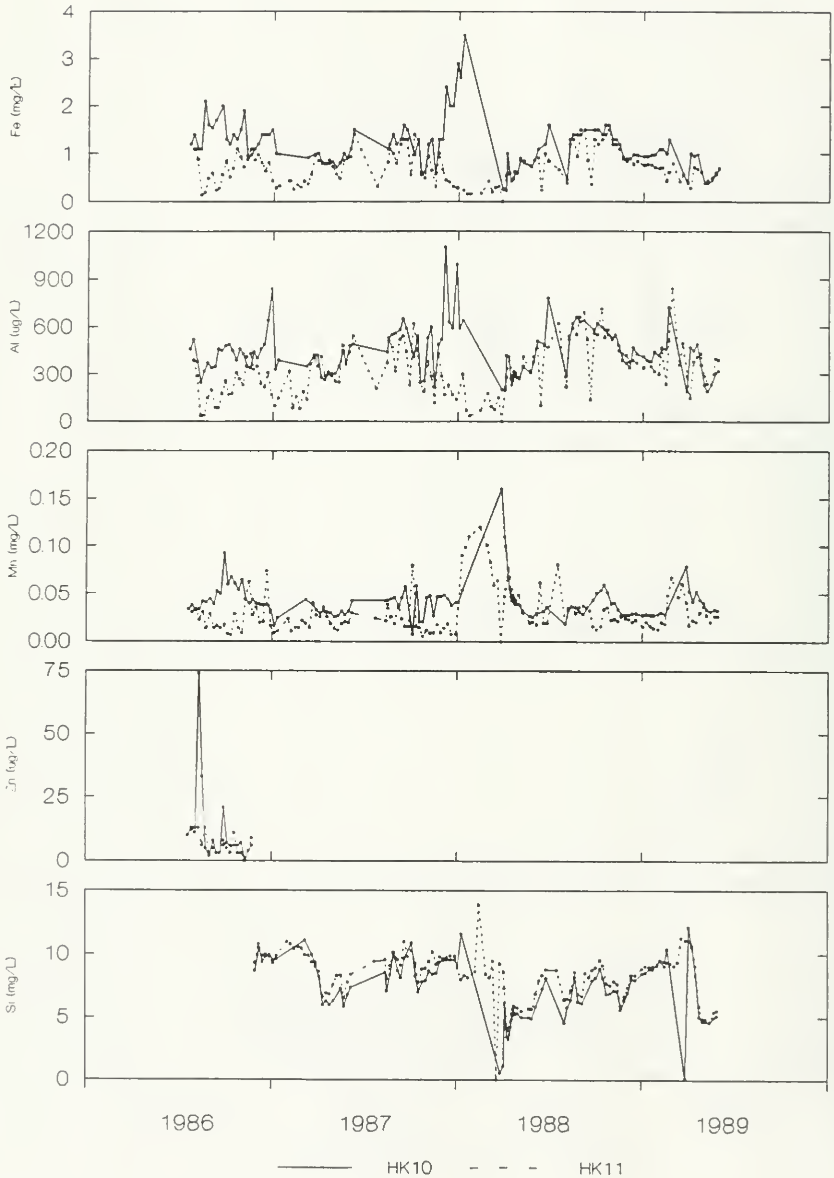


Figure 7d continued

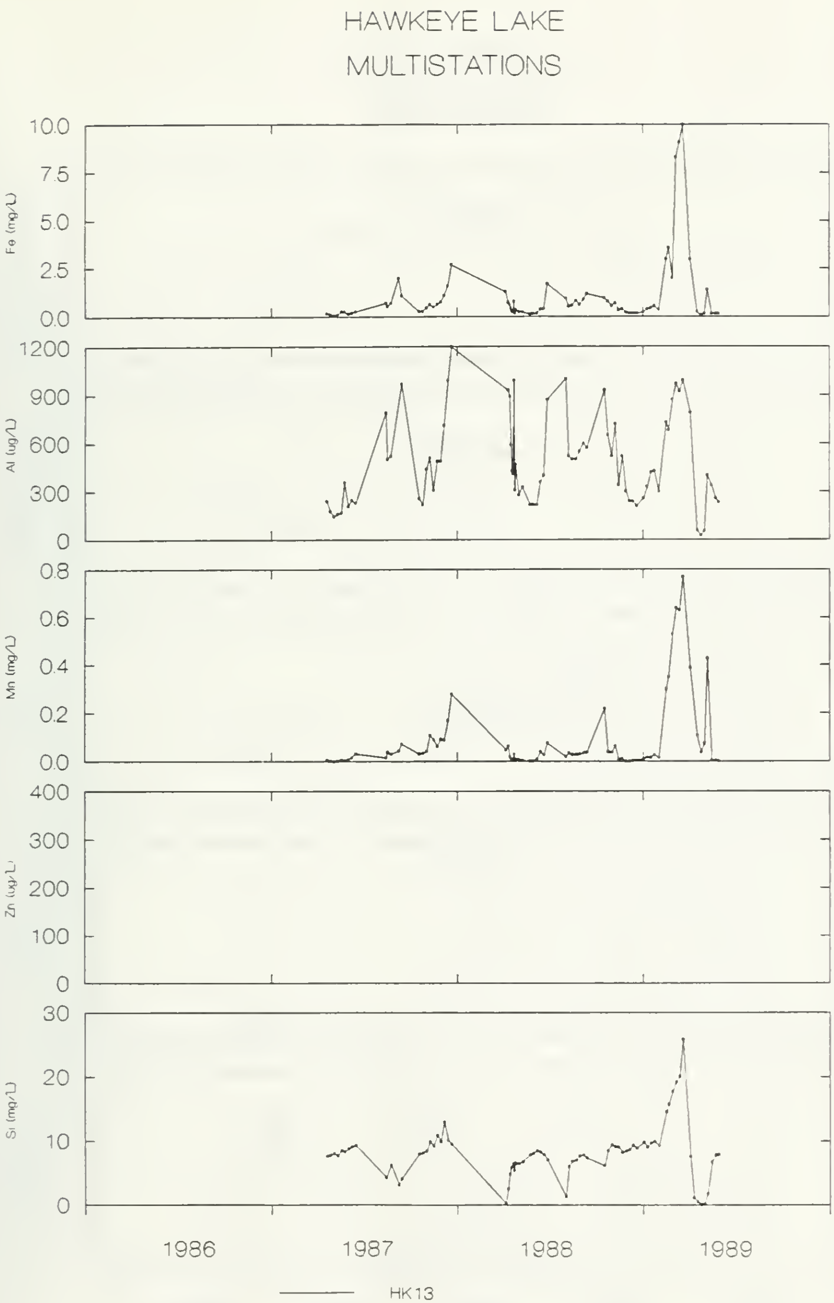
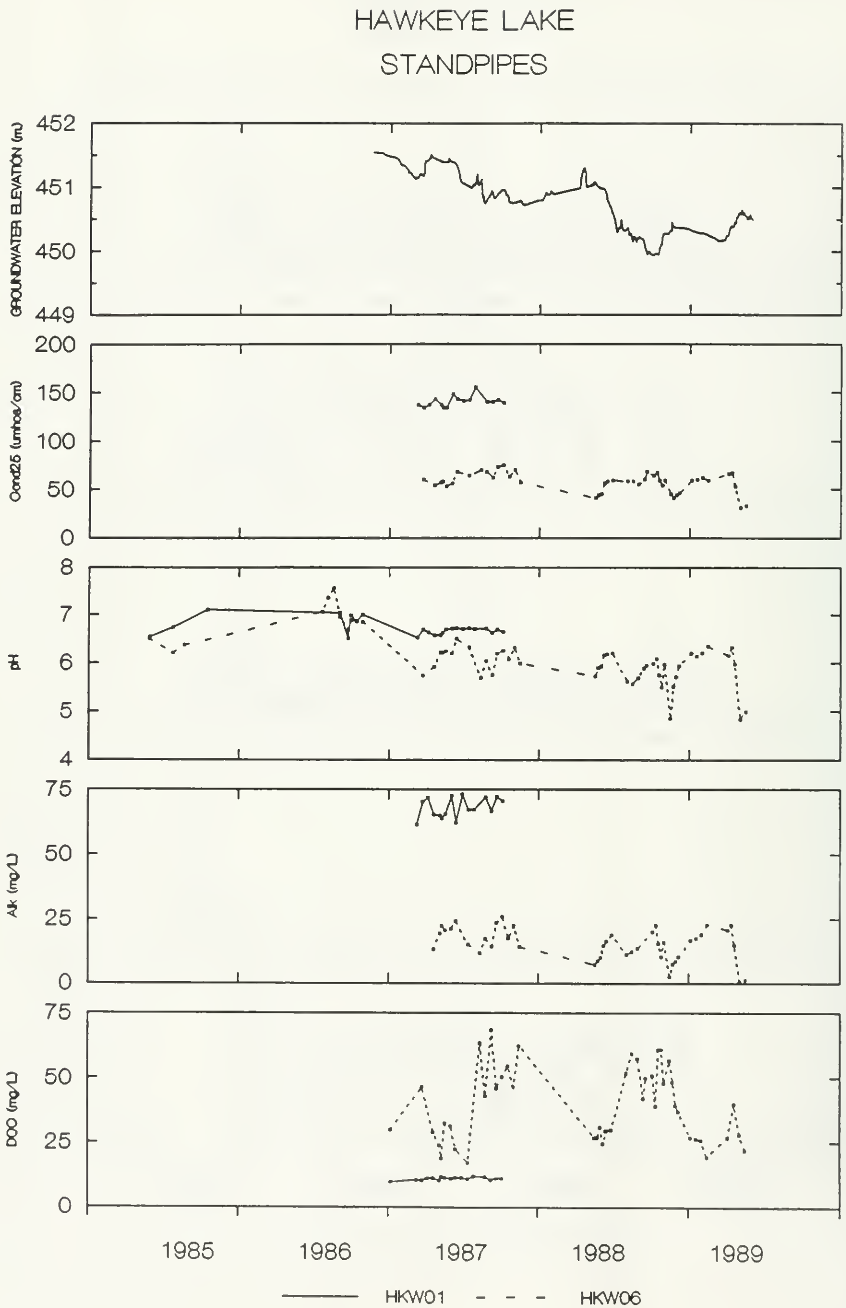


Figure 7d continued



HAWKEYE LAKE
STANDPIPES
GROUNDWATER ELEVATION (m)
452
451
450
449
Cond25 (umhos/cm)
200
150
100
50
0
pH
8
7
6
5
4
Alk (mg/L)
75
50
25
0
DOO (mg/L)
75
50
25
0
1985
1986
1987
1988
1989
HKW01
HKW06

Figure 8a

HAWKEYE LAKE
STANDPIPES

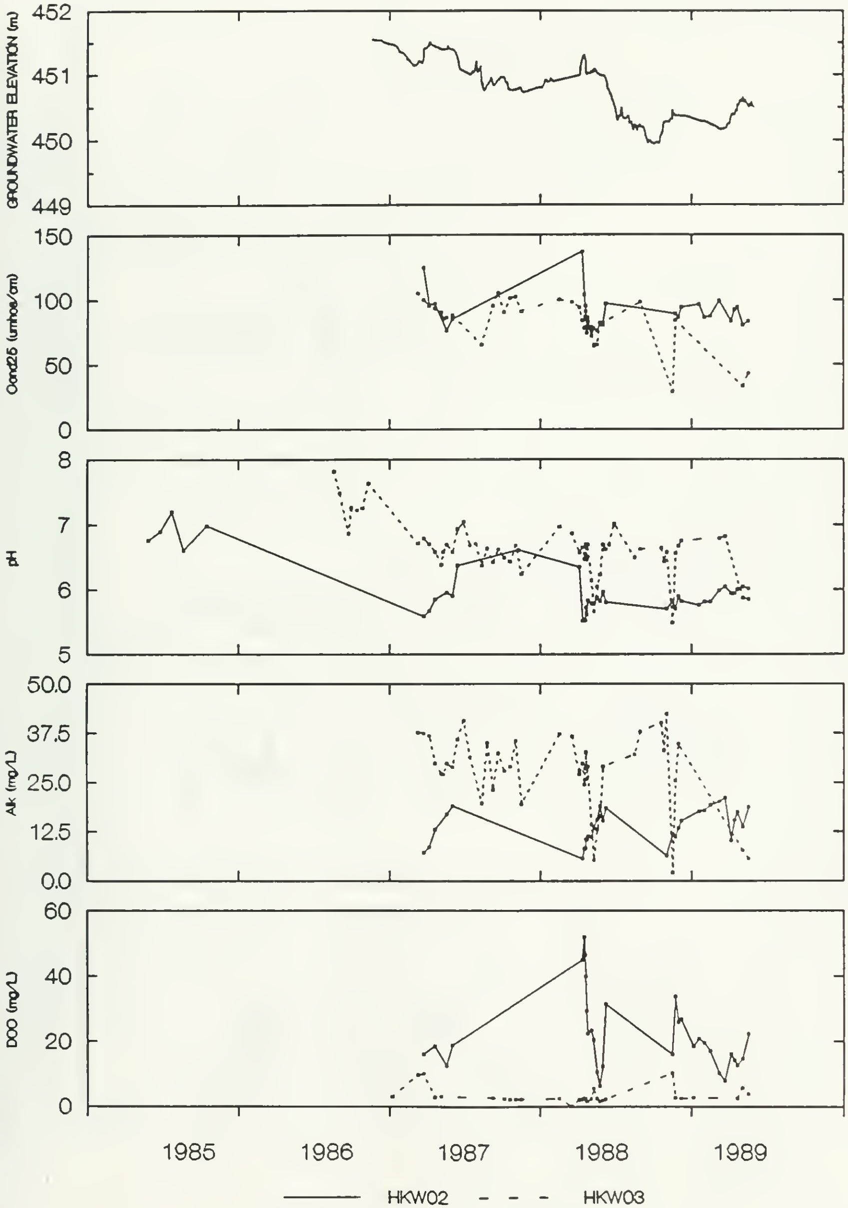


Figure 8a continued

HAWKEYE LAKE
STANDPIPES

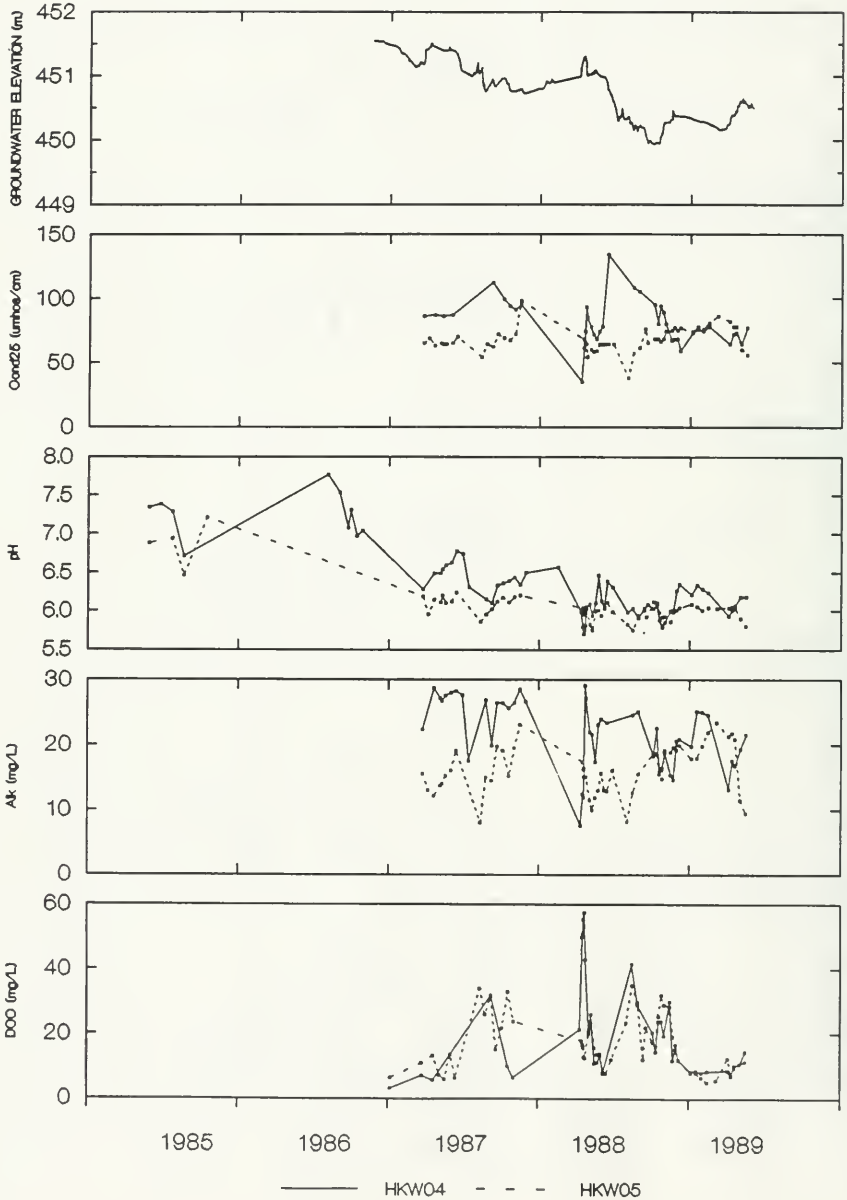


Figure 8a continued

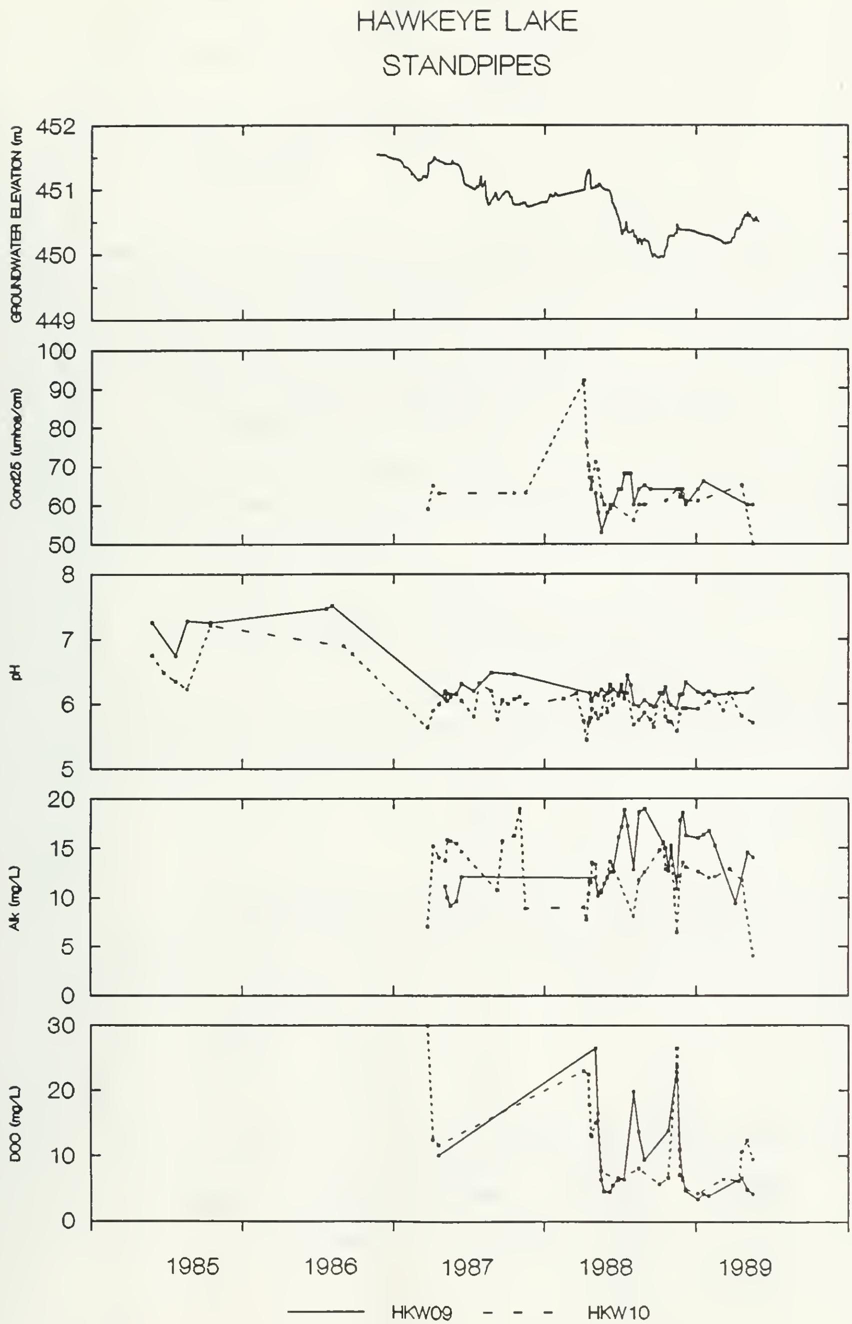


Figure 8a continued

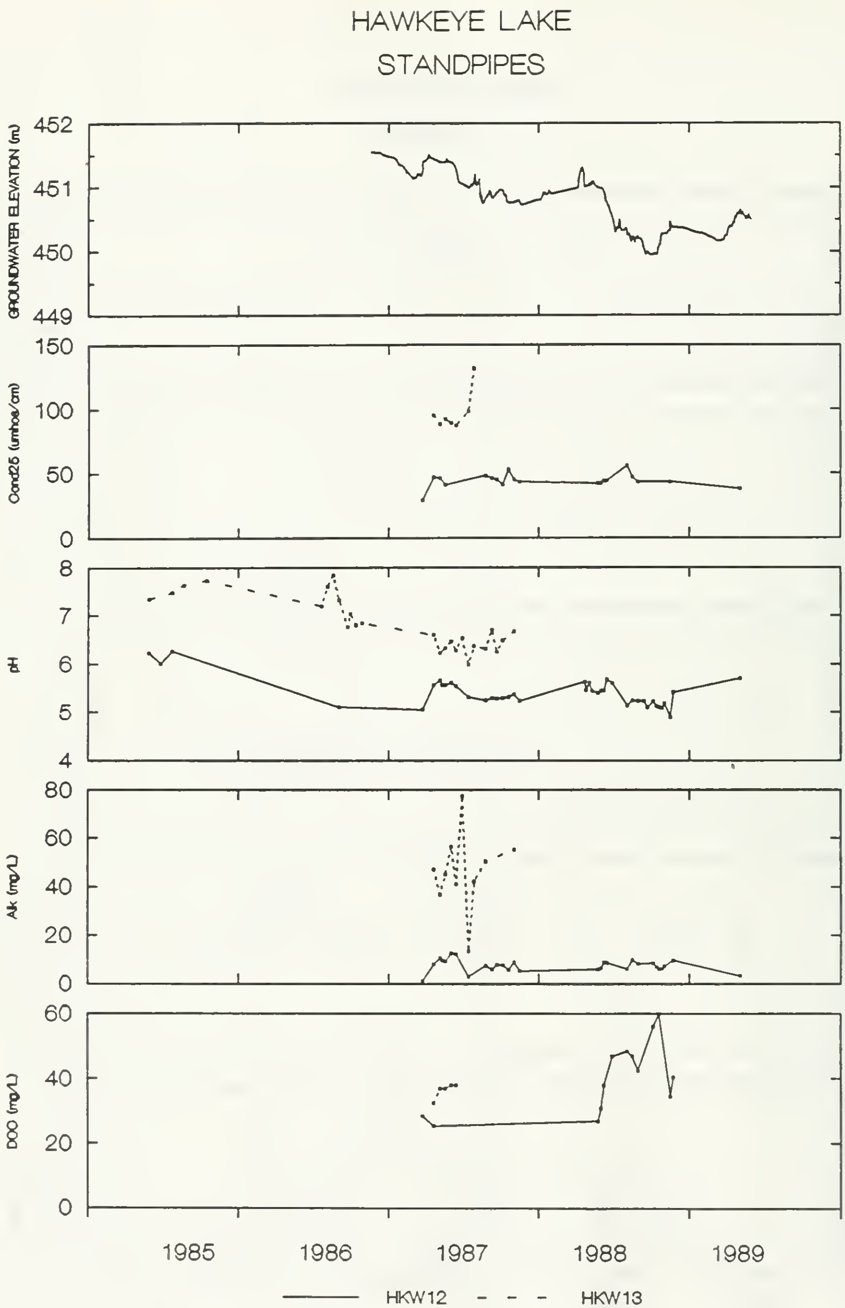


Figure 8a continued

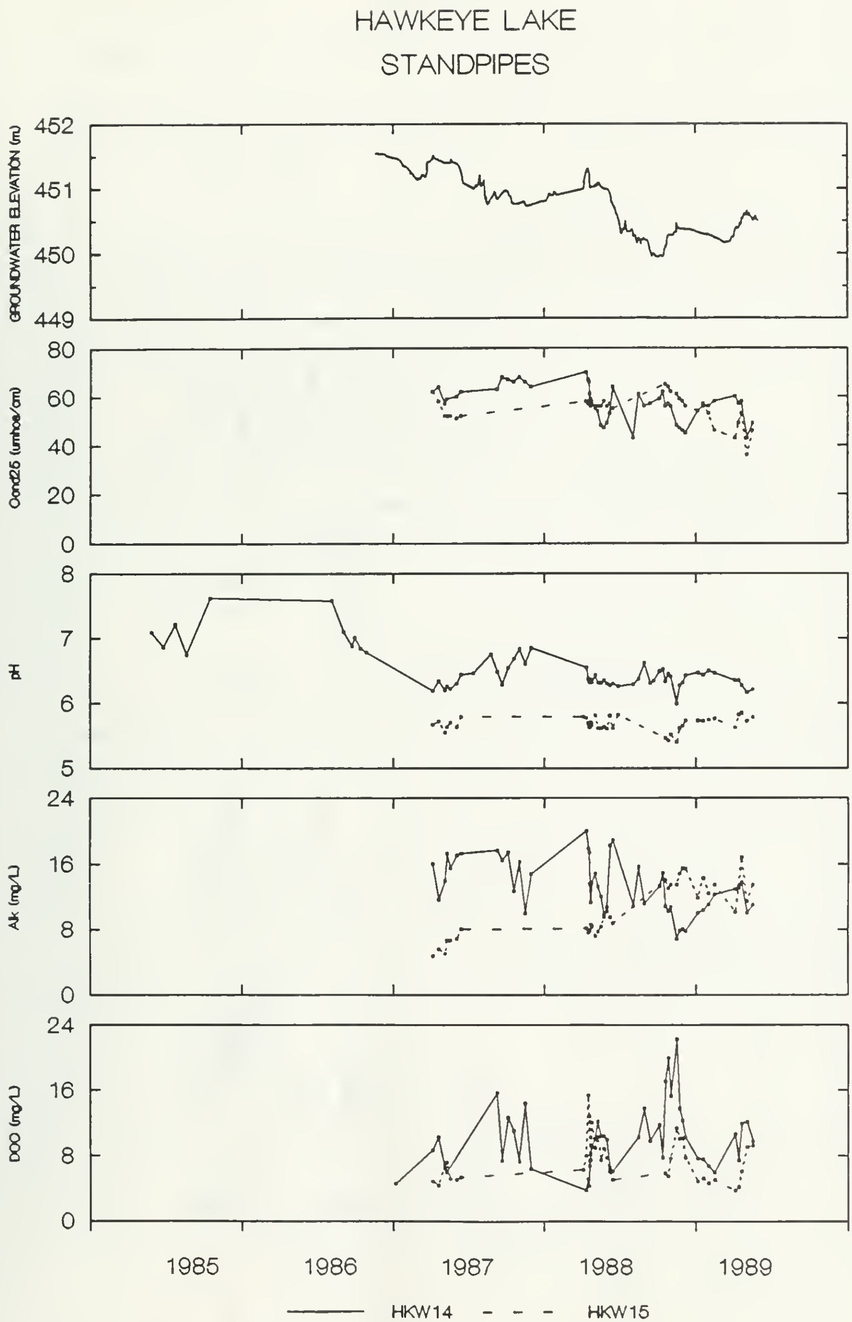


Figure 8a continued

HAWKEYE LAKE
STANDPIPES

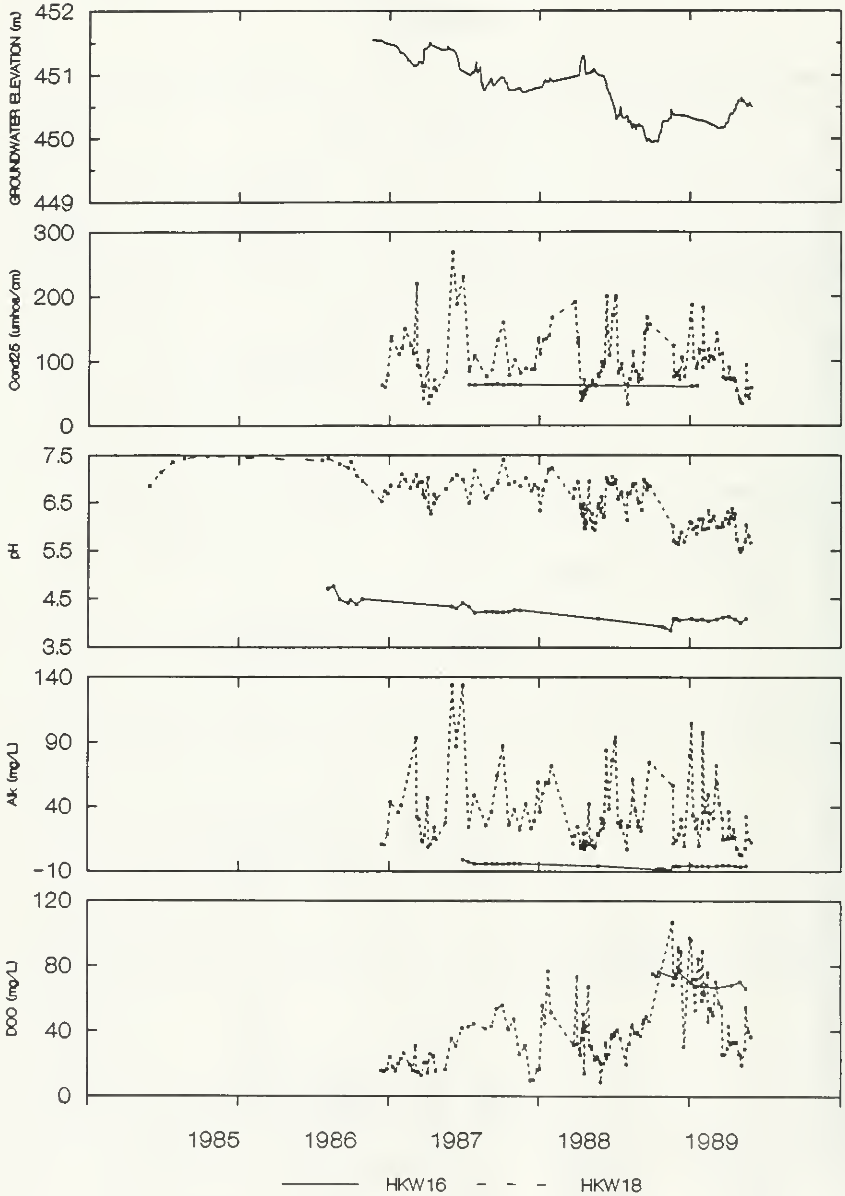


Figure 8a continued

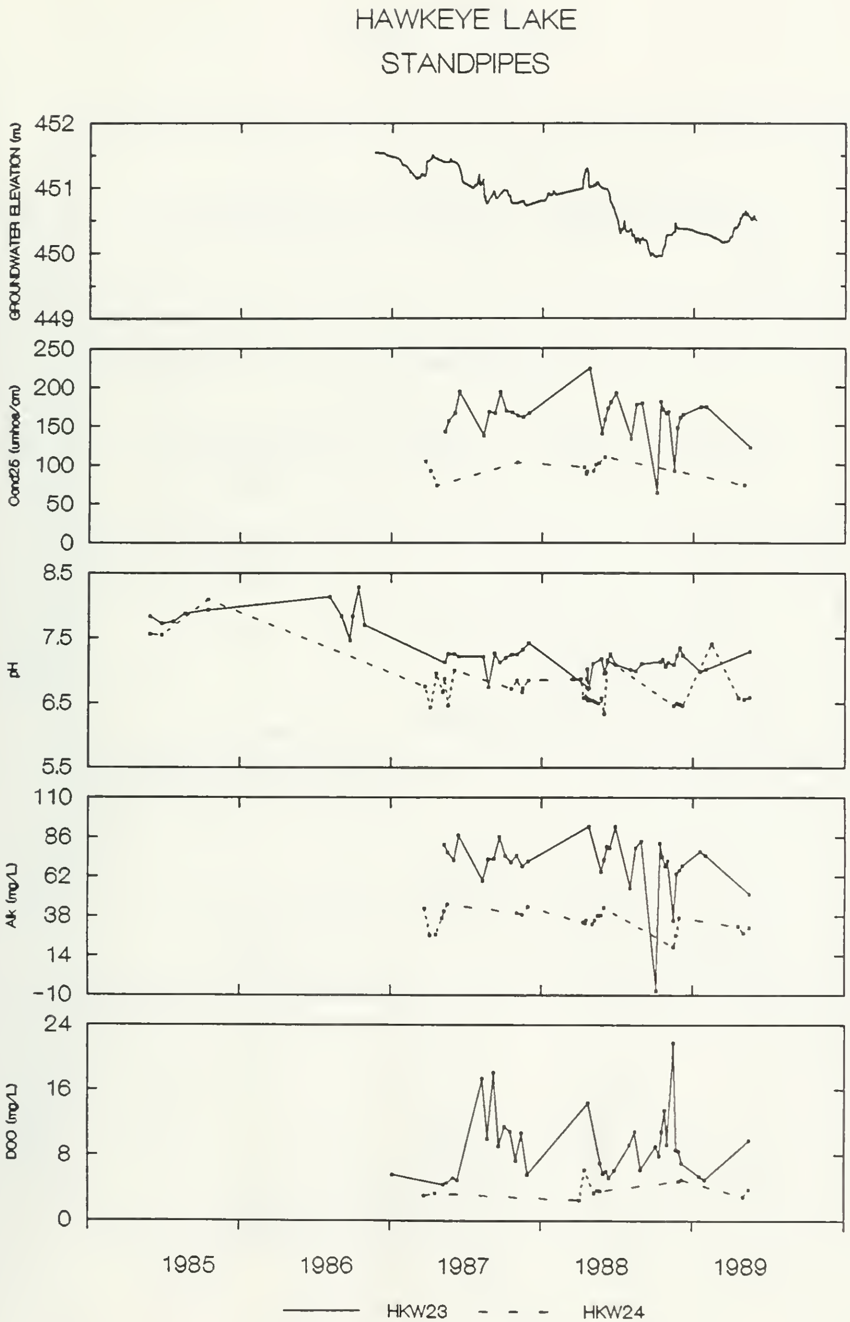


Figure 8a continued

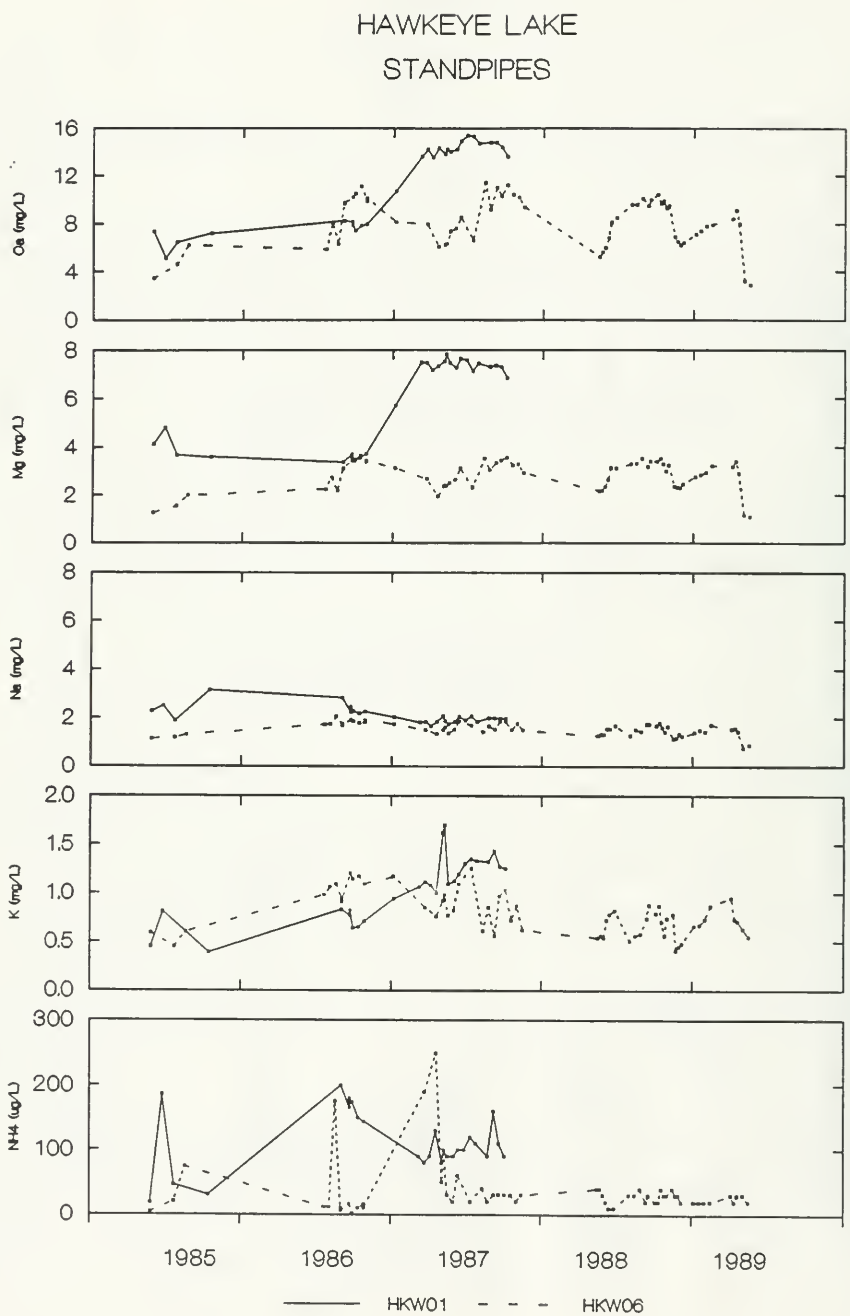

HAWKEYE LAKE
STANDPIPES
Ca (mg/L)
Mg (mg/L)
Na (mg/L)
K (mg/L)
NH4 (ug/L)
16
12
8
4
0
6
2
2.0
1.5
1.0
0.5
0.0
300
200
100
1985
1986
1987
1988
1989
HKW01
HKW06

Figure 8b

HAWKEYE LAKE
STANDPIPES

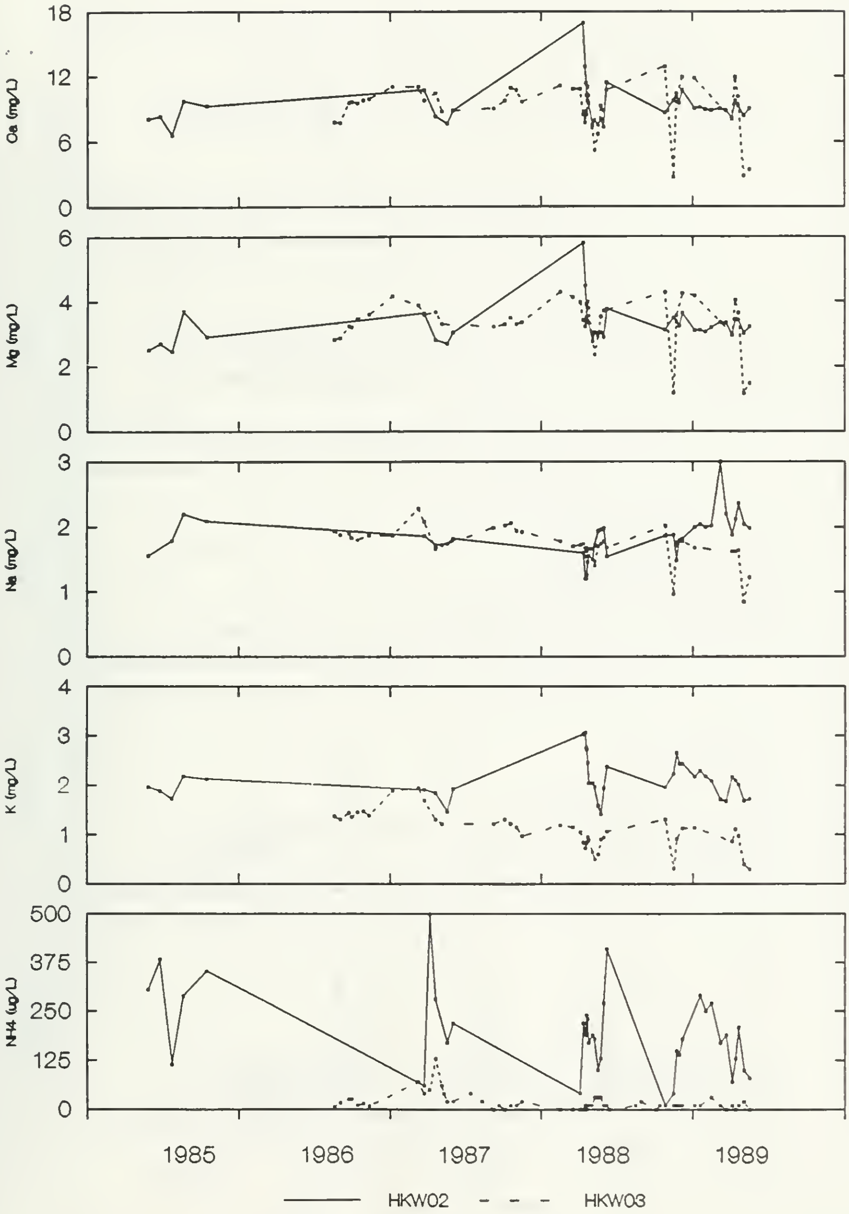


Figure 8b continued

HAWKEYE LAKE
STANDPIPES

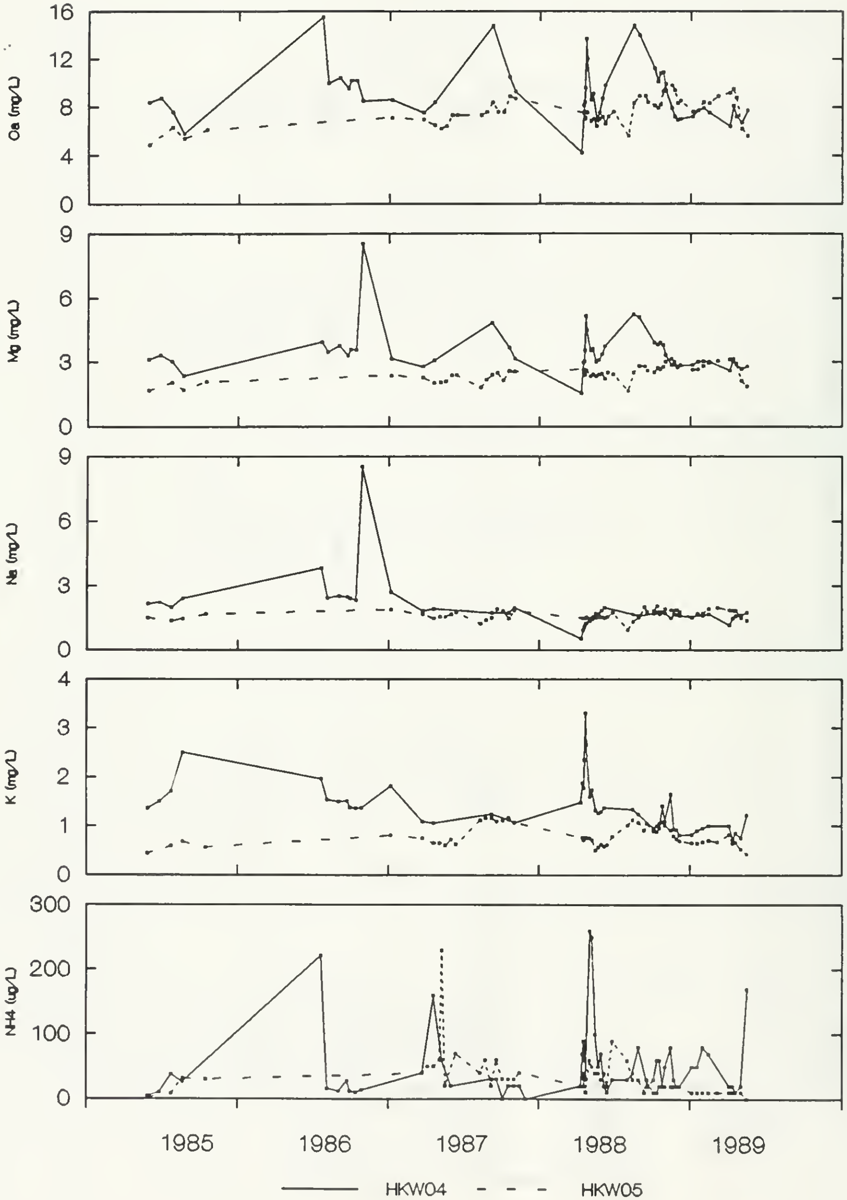


Figure 8b continued

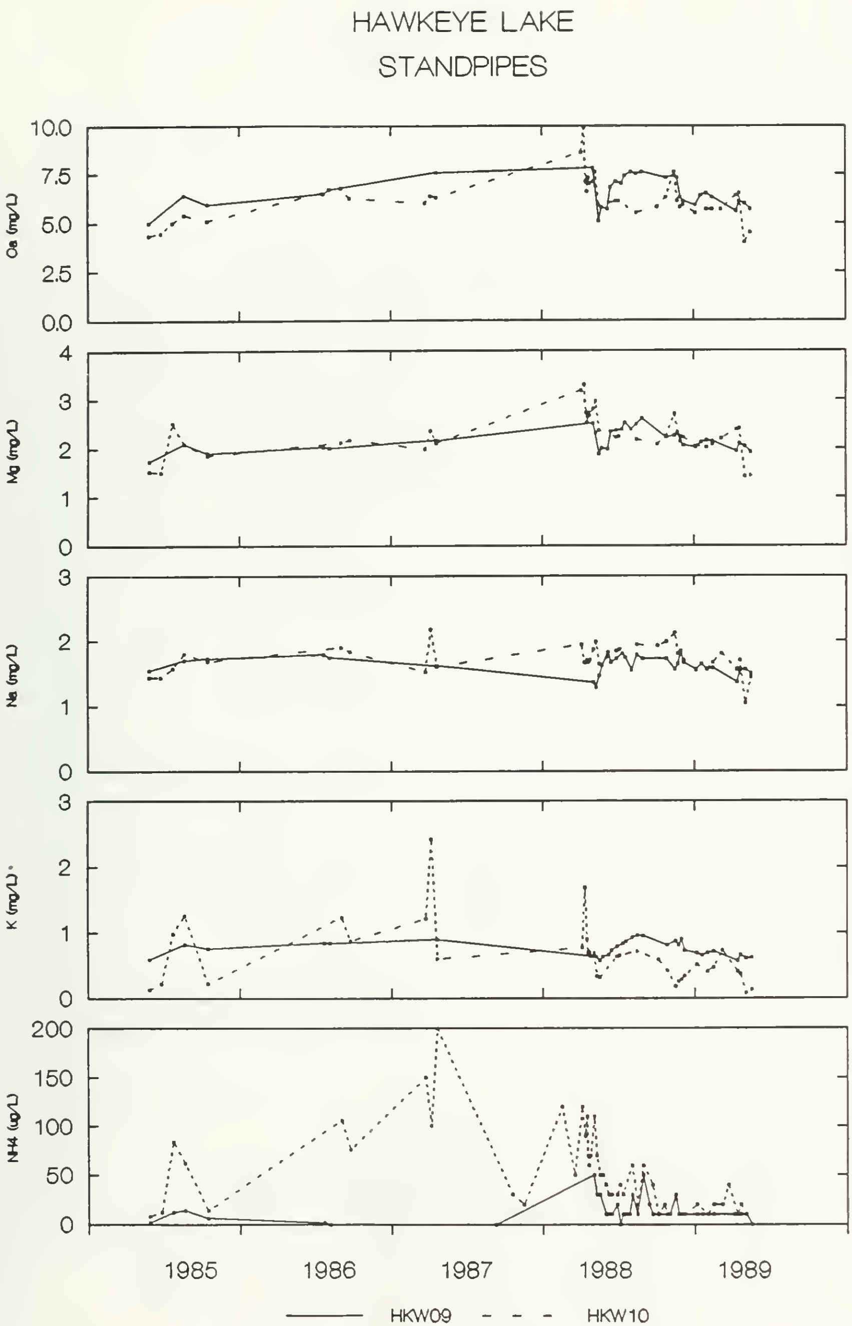


Figure 8b continued

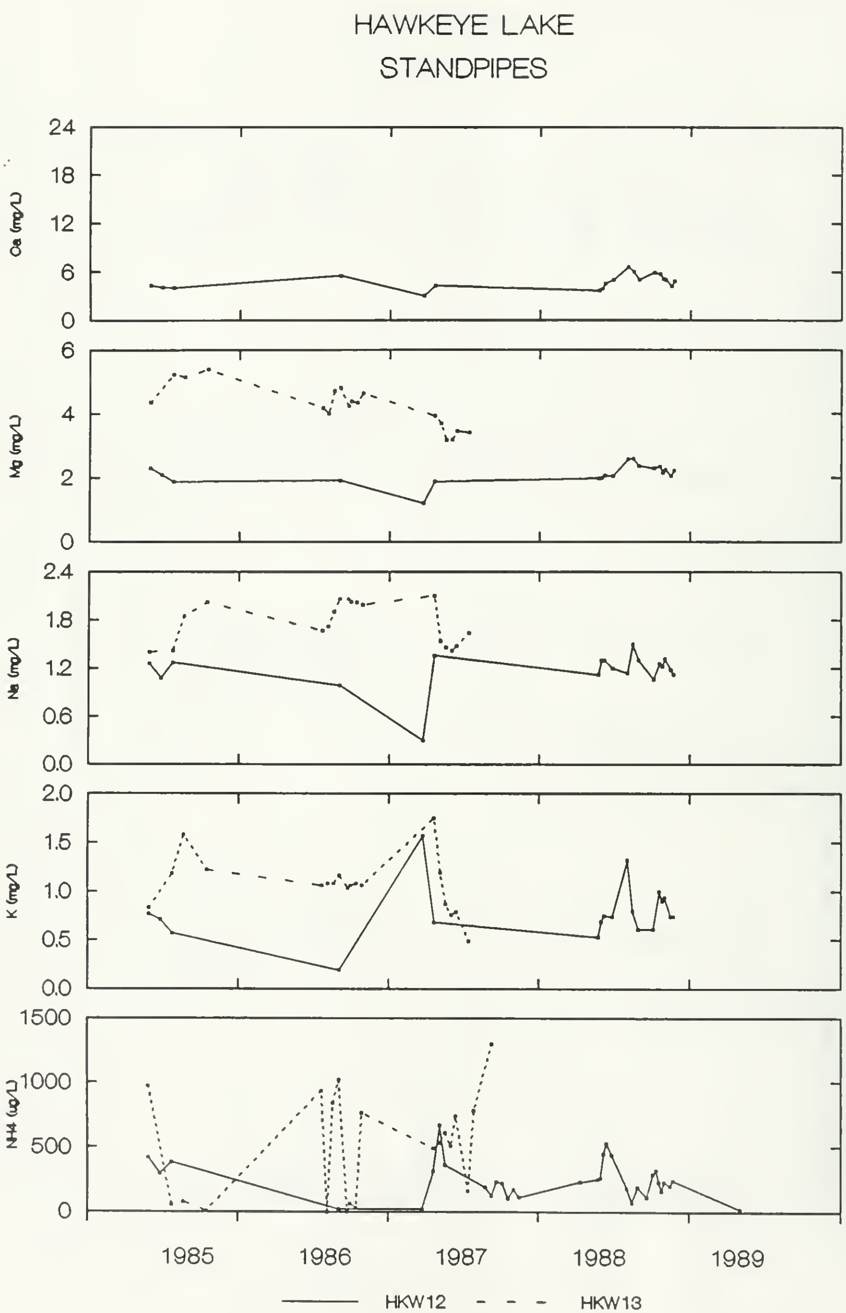


Figure 8b continued

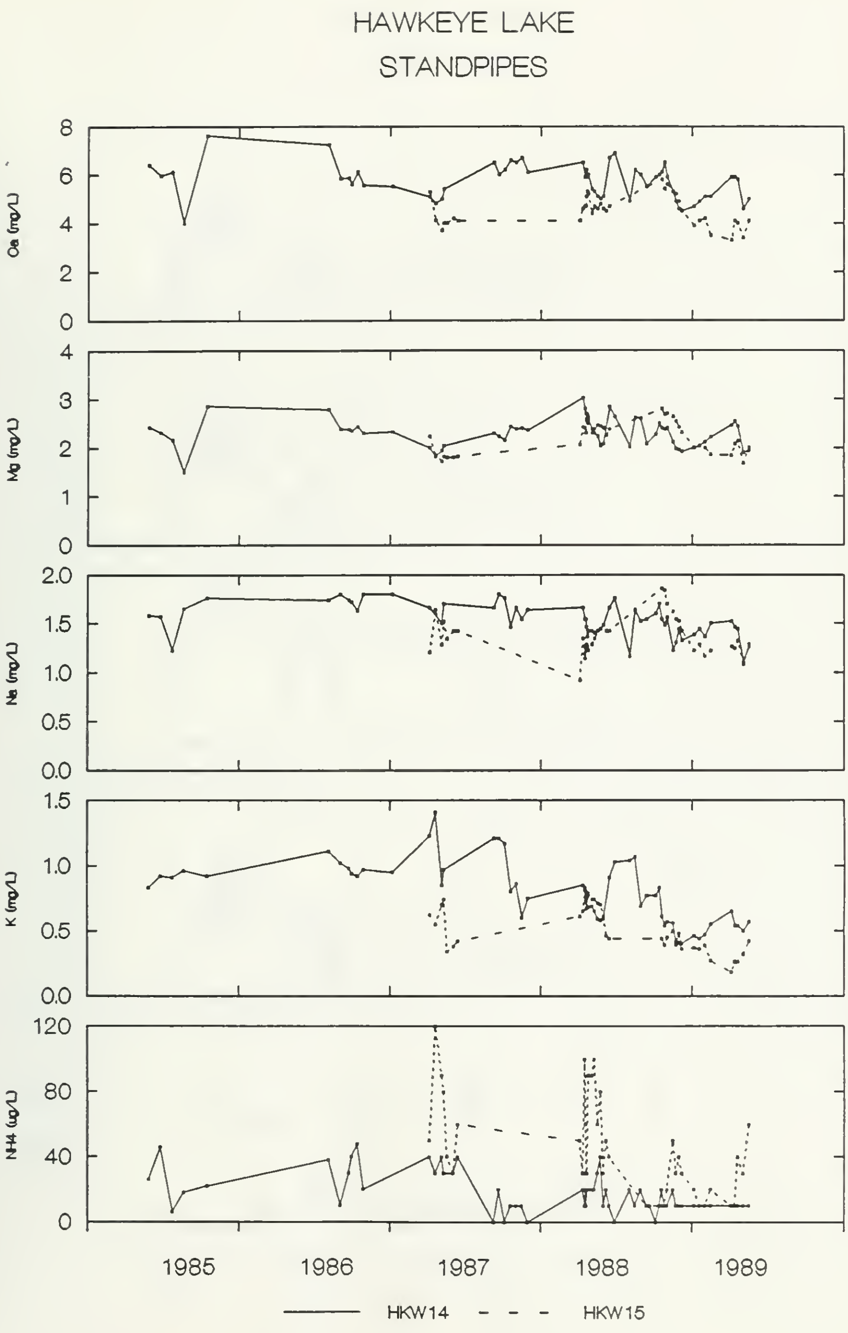


Figure 8b continued

HAWKEYE LAKE
STANDPIPES

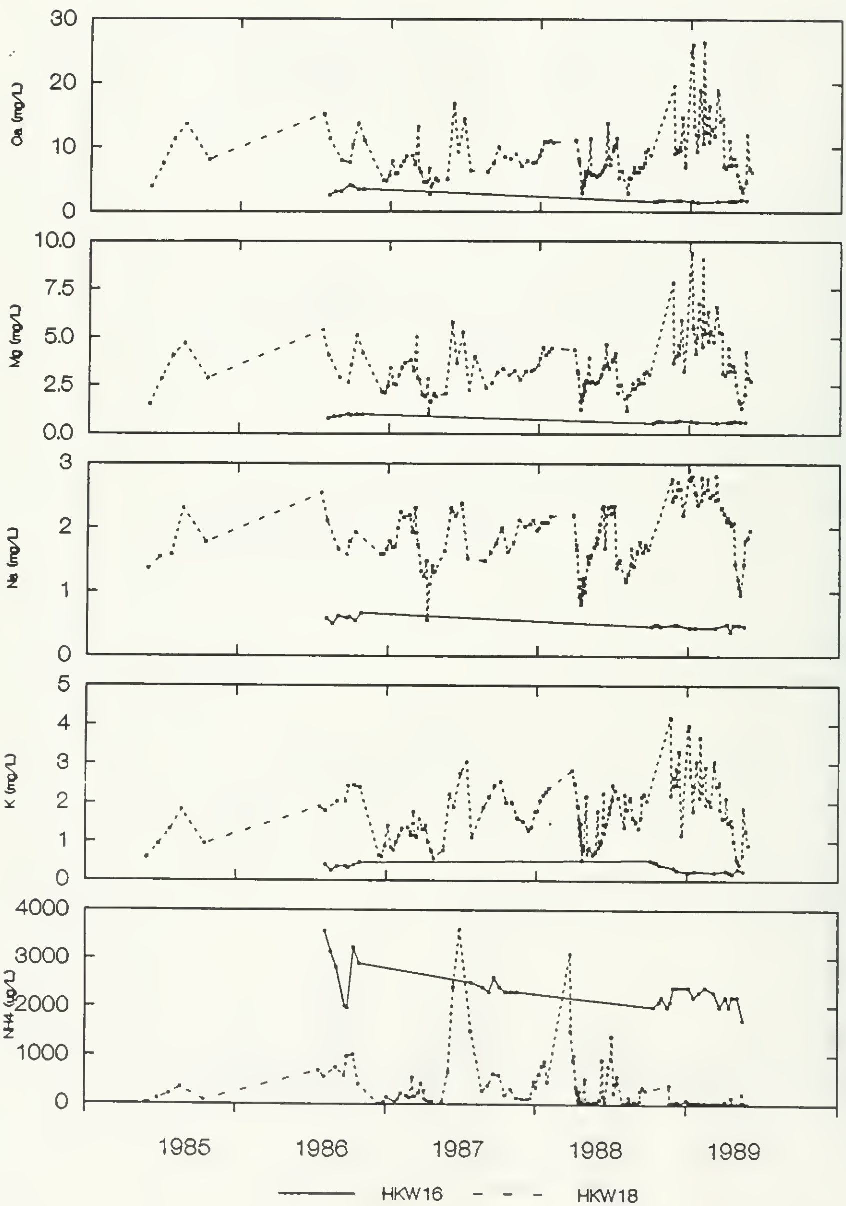


Figure 8b continued

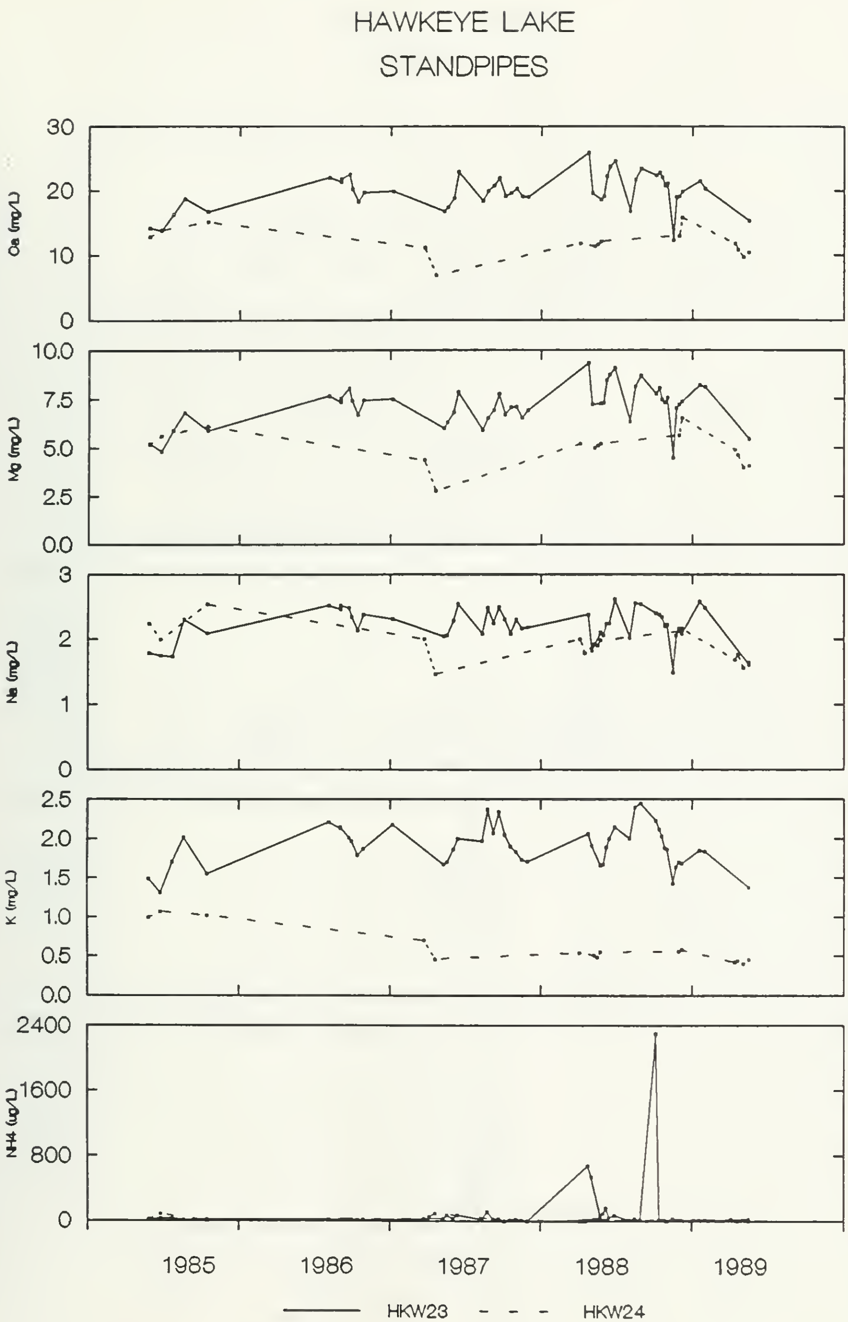


Figure 8b continued

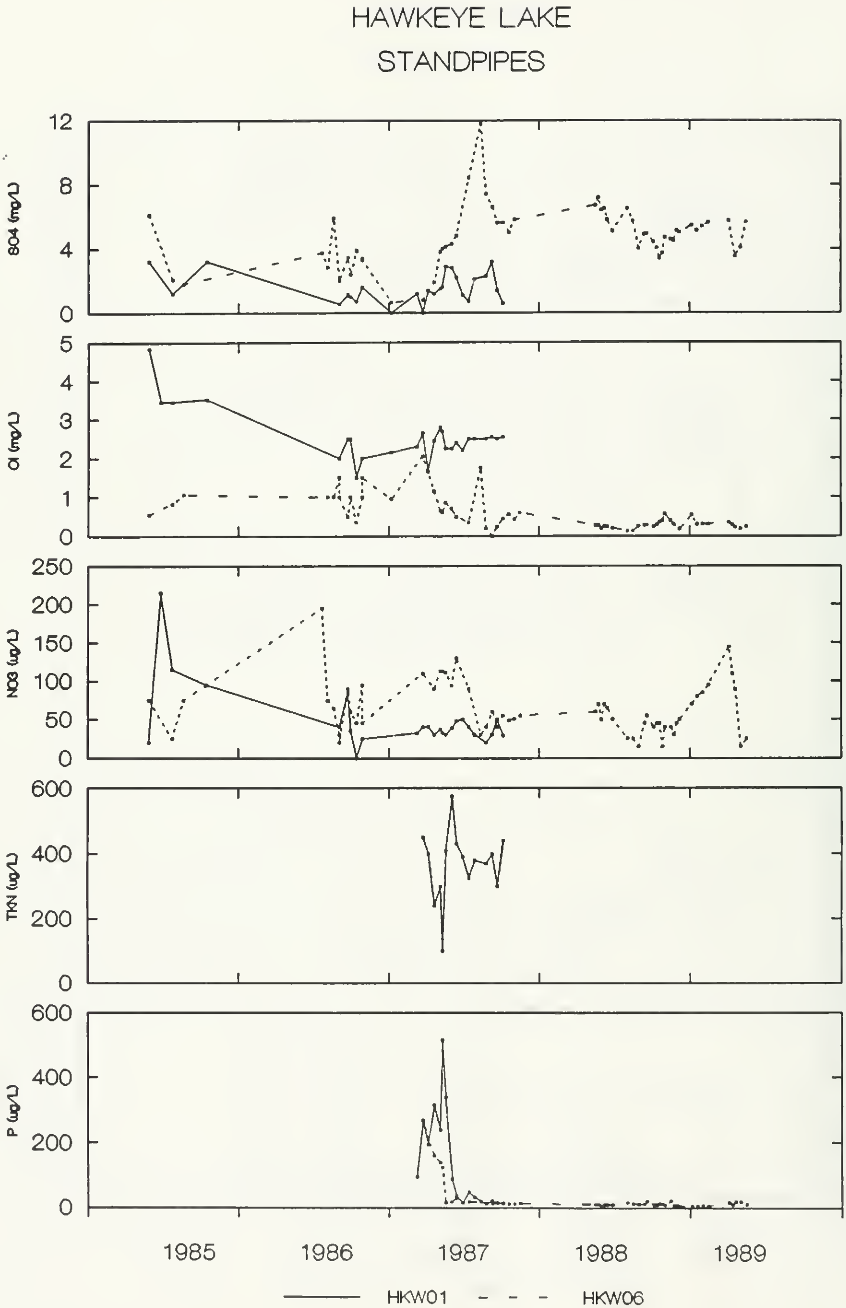

HAWKEYE LAKE
STANDPIPES
SO4 (mg/L)
12
8
4
0
Cl (mg/L)
5
4
3
2
1
0
NO3 (ug/L)
250
200
150
100
50
0
TKN (ug/L)
600
400
200
0
P (ug/L)
600
400
200
0
1985
1986
1987
1988
1989
HKW01
HKW06

Figure 8c

HAWKEYE LAKE
STANDPIPES

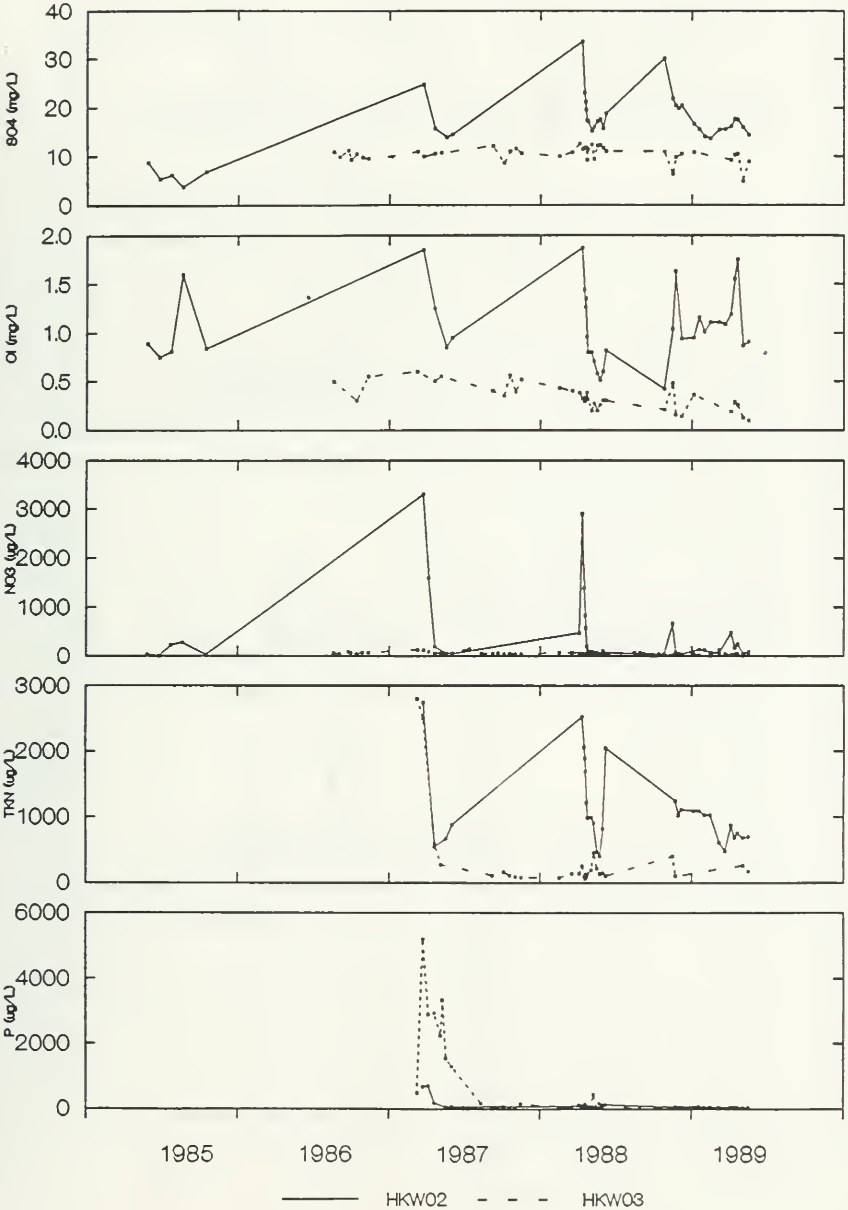


Figure 8c continued

HAWKEYE LAKE
STANDPIPES

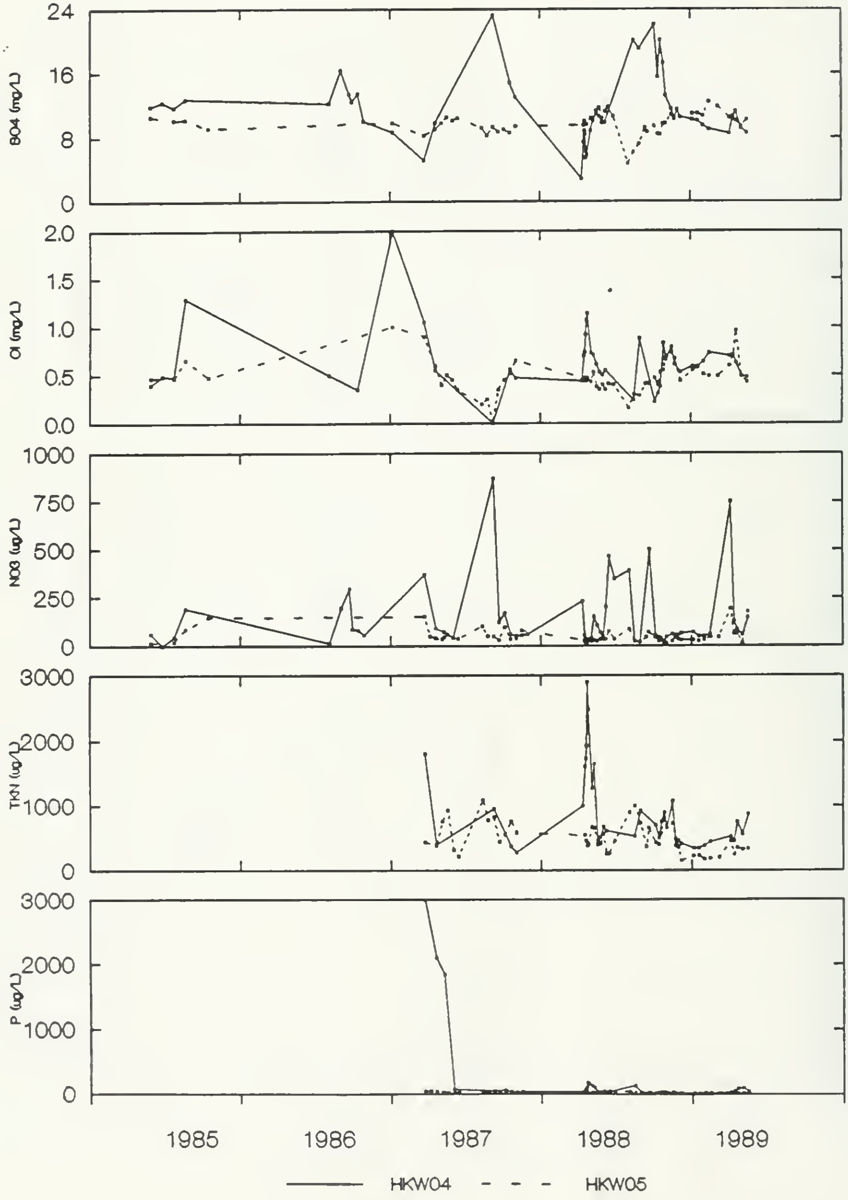


Figure 8c continued

HAWKEYE LAKE
STANDPIPES

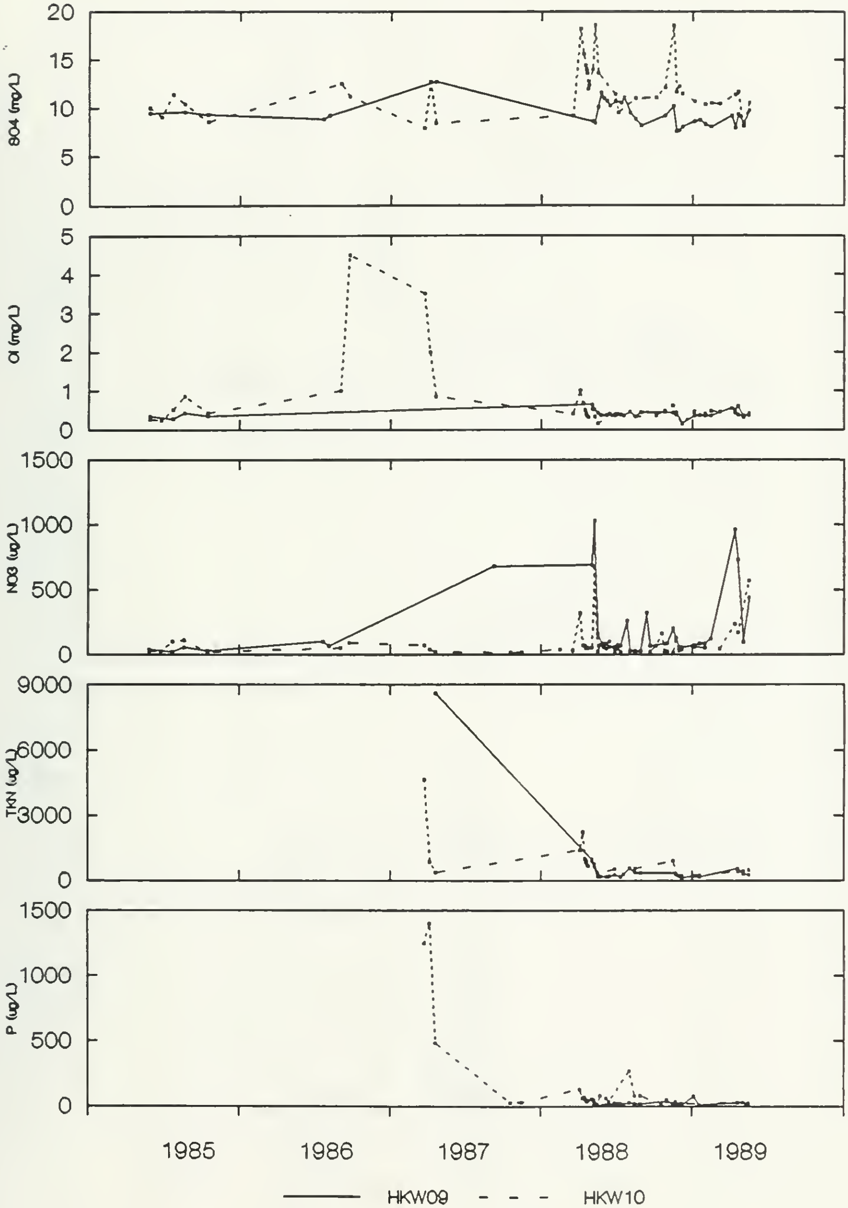


Figure 8c continued

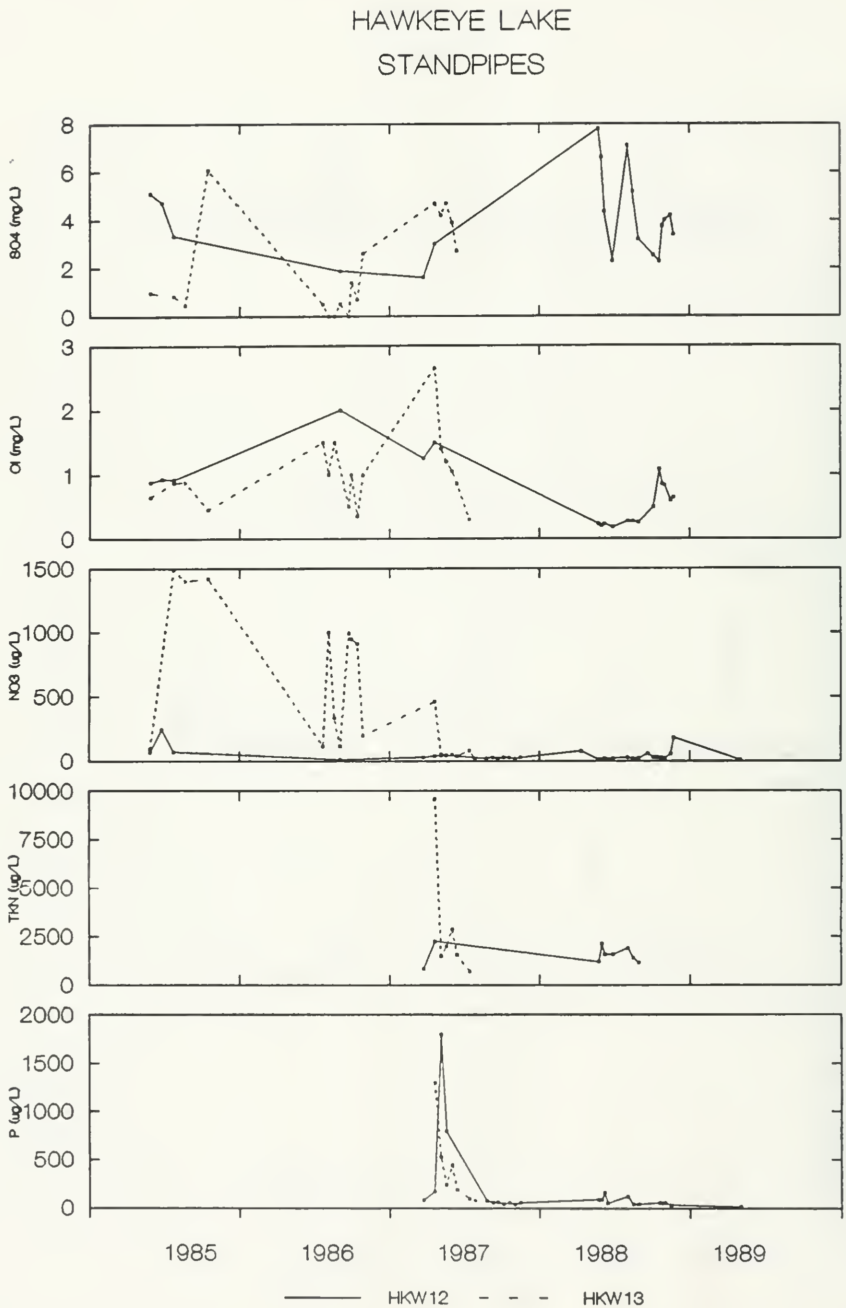


Figure 8c continued

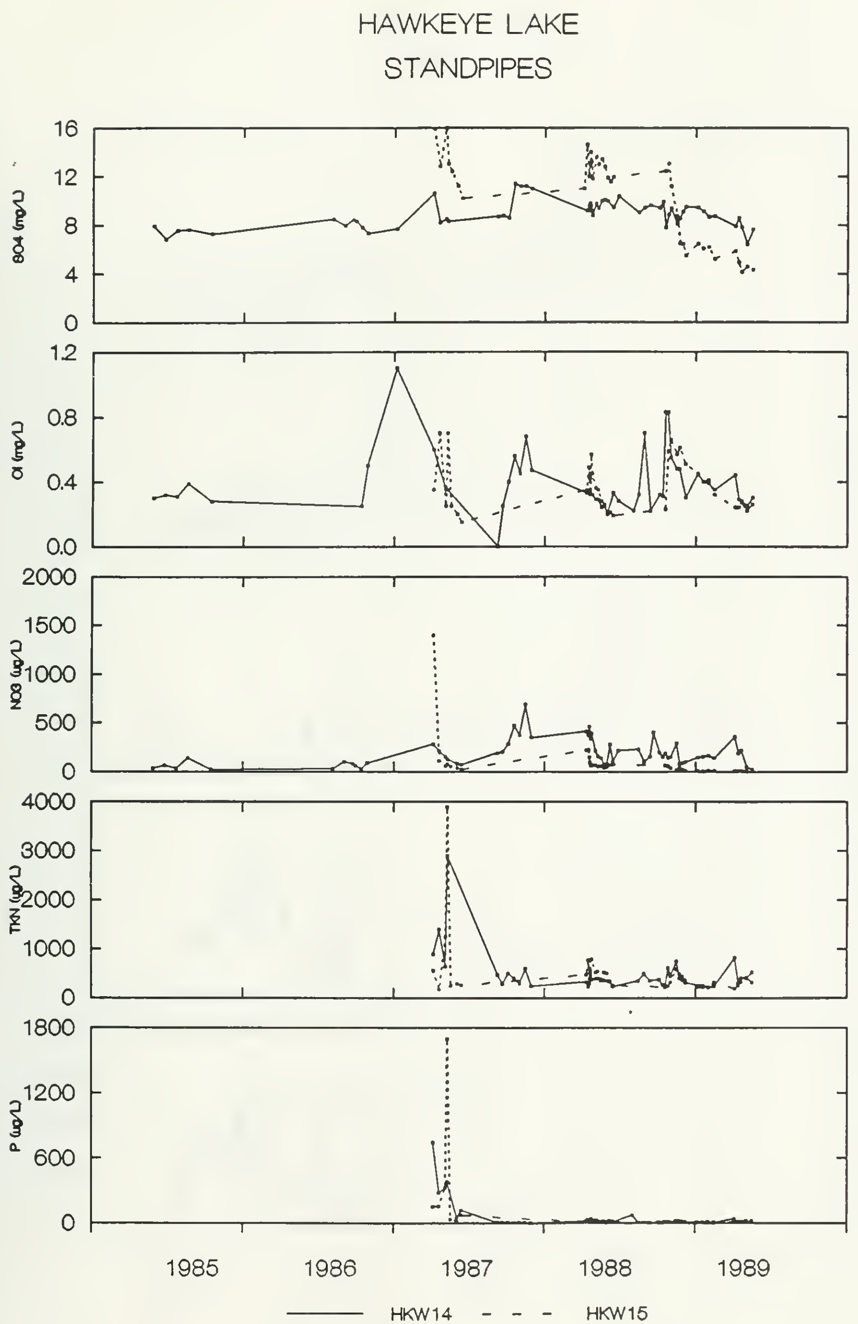


Figure 8c continued

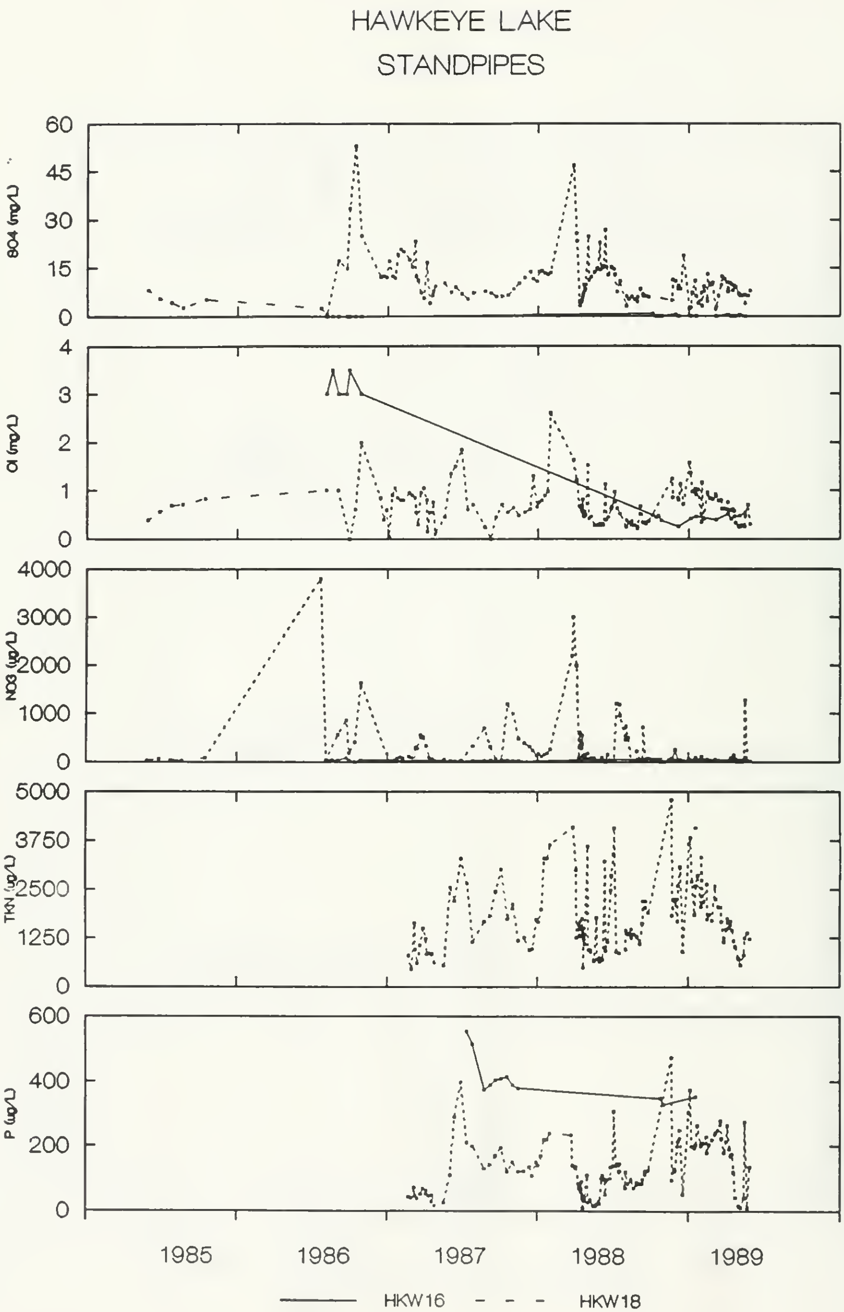


Figure 8c continued

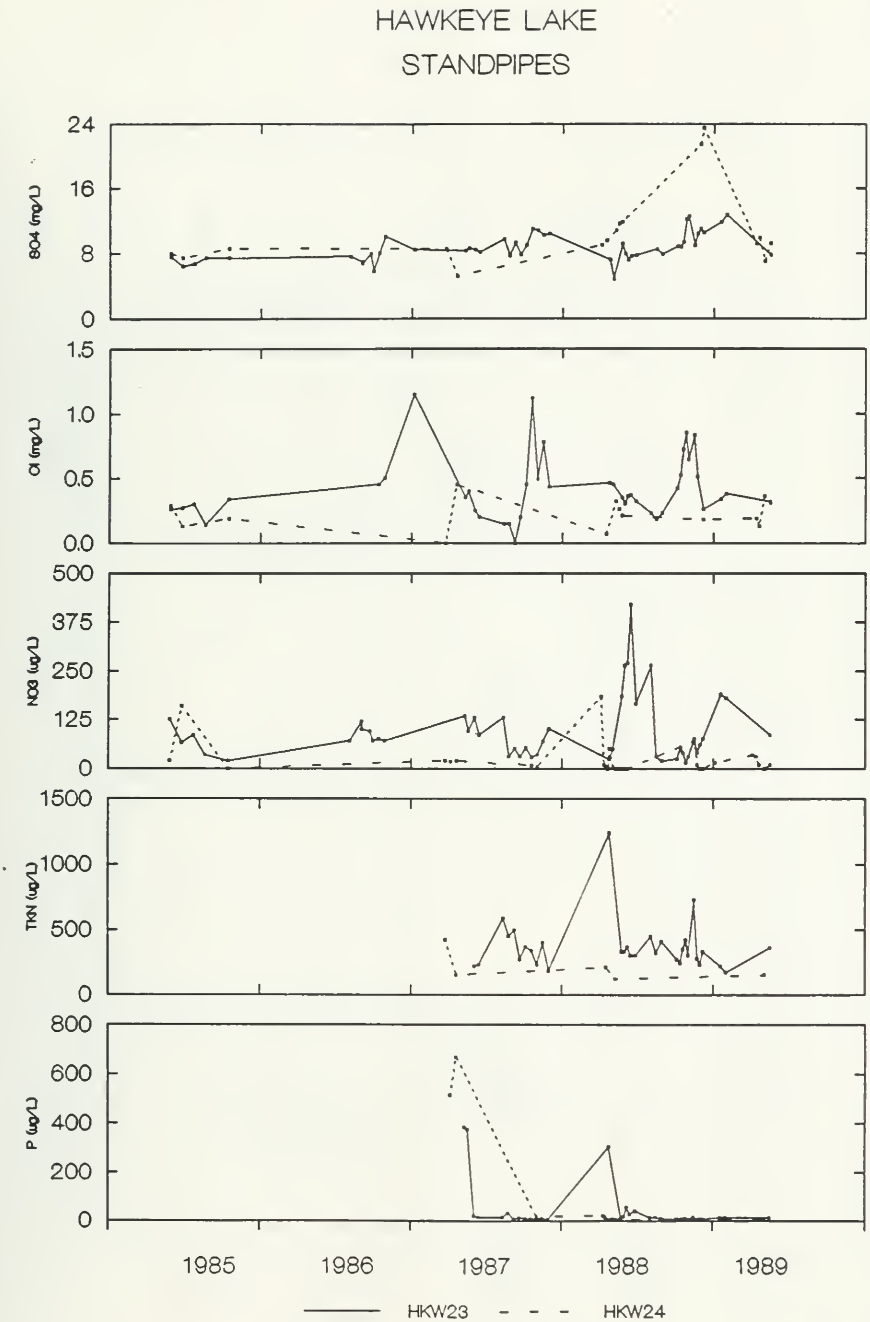


Figure 8c continued

HAWKEYE LAKE
STANDPIPES

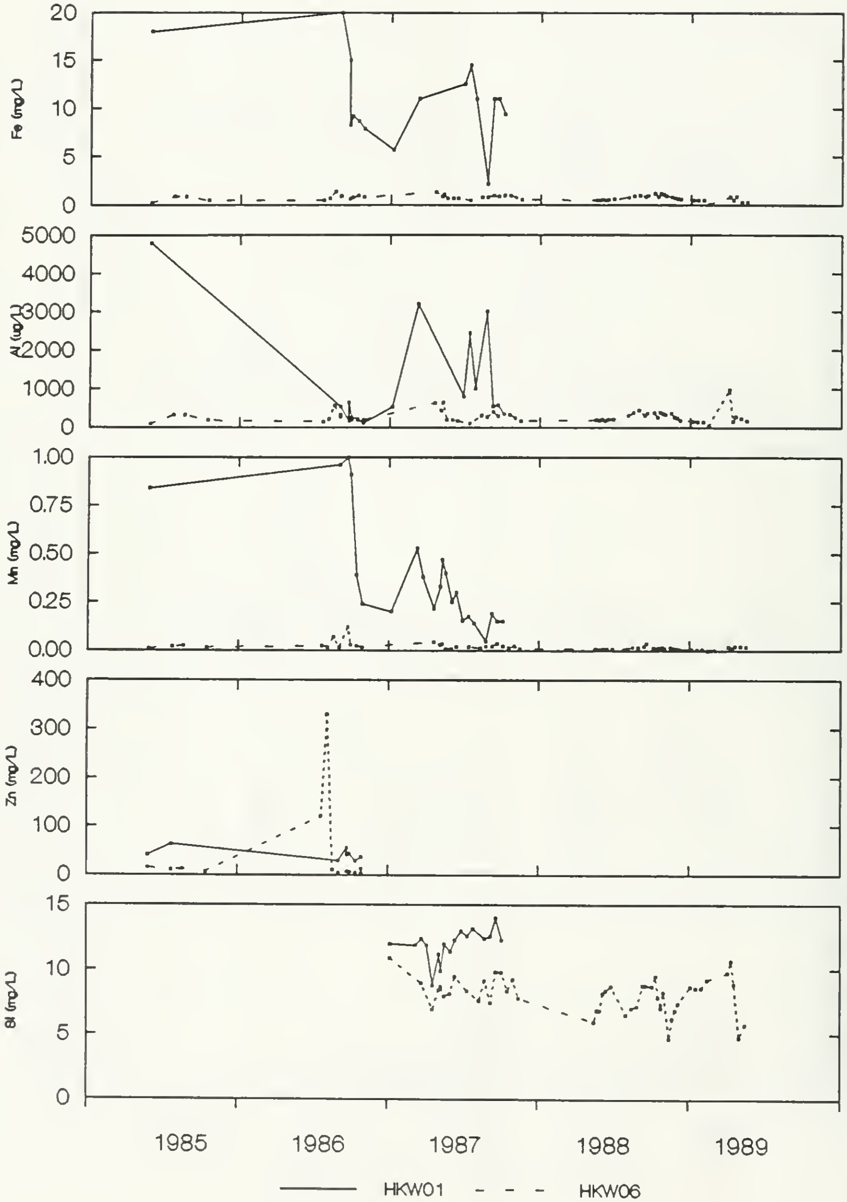


Figure 8d

HAWKEYE LAKE
STANDPIPES

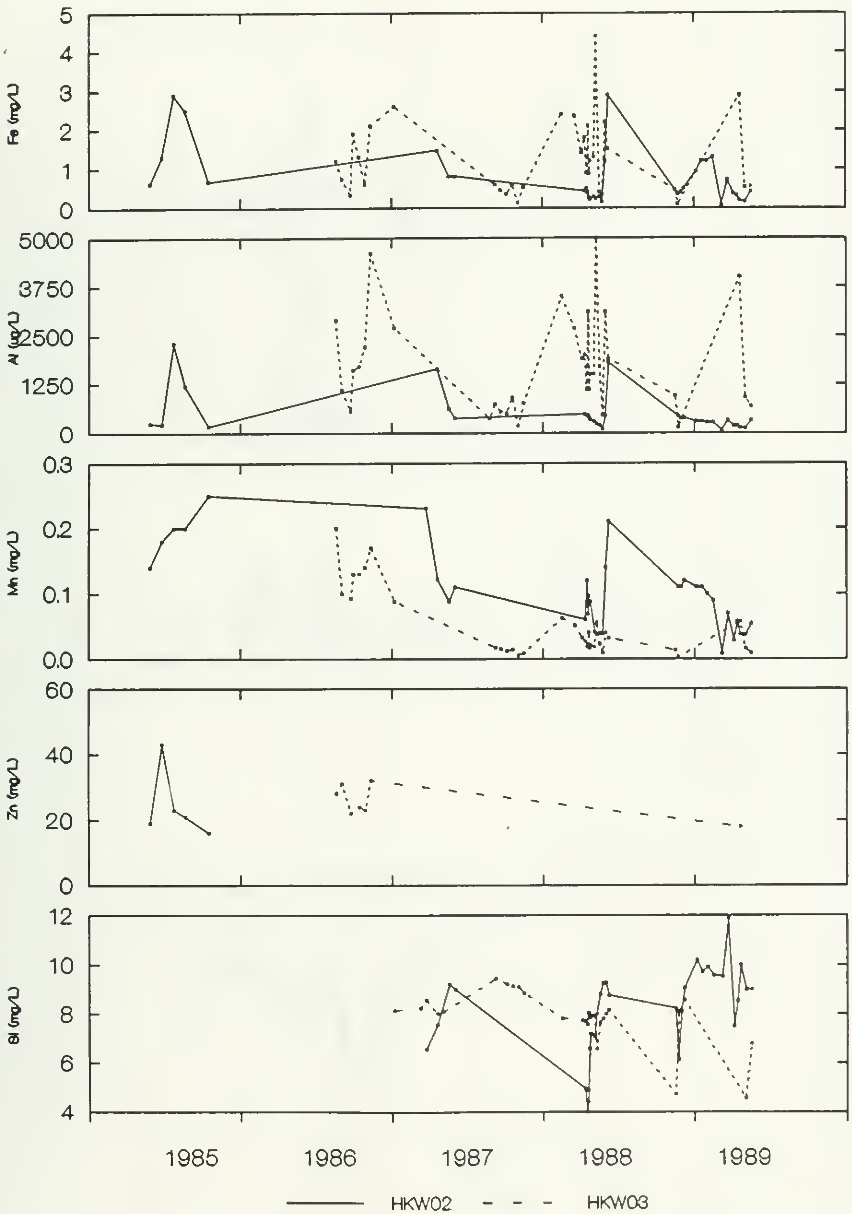


Figure 8d continued

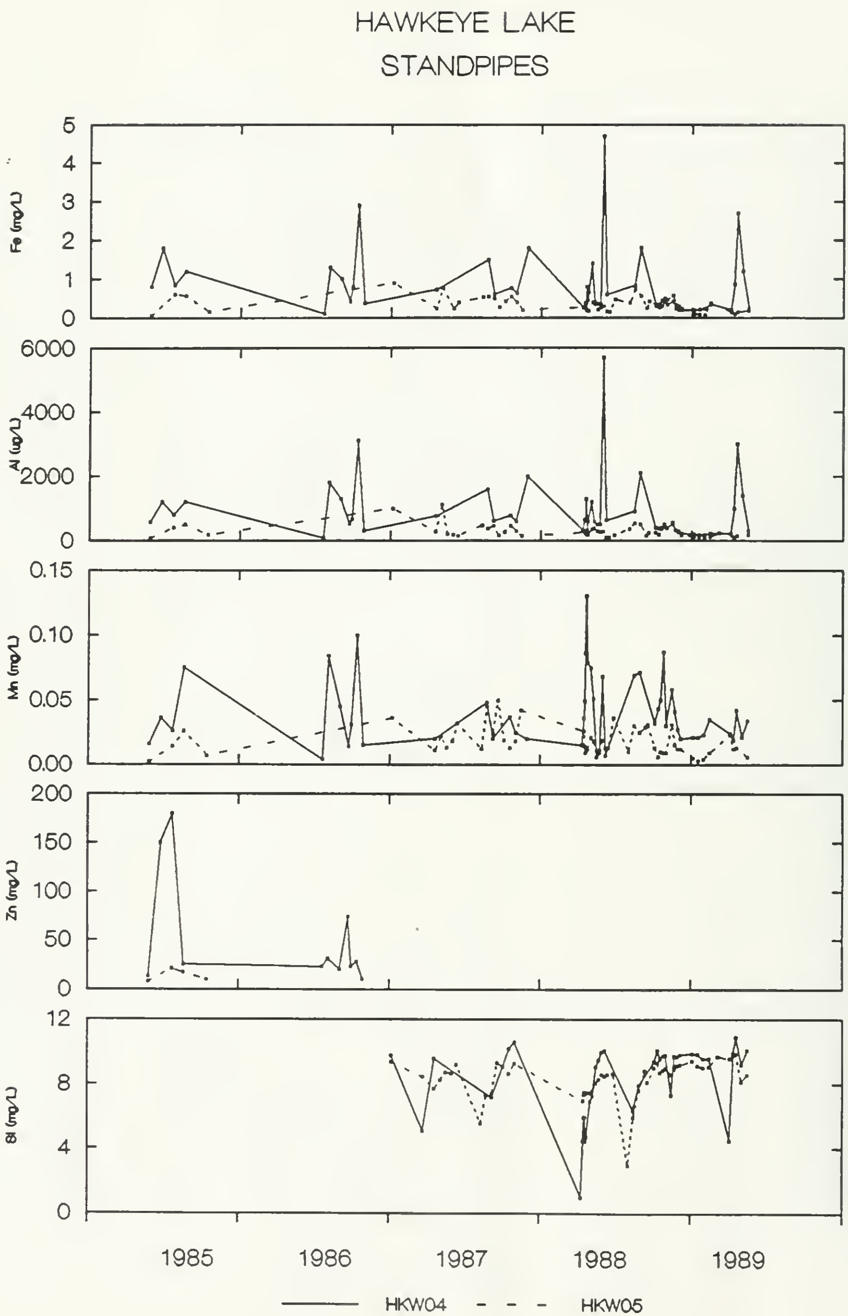


Figure 8d continued

HAWKEYE LAKE
STANDPIPES

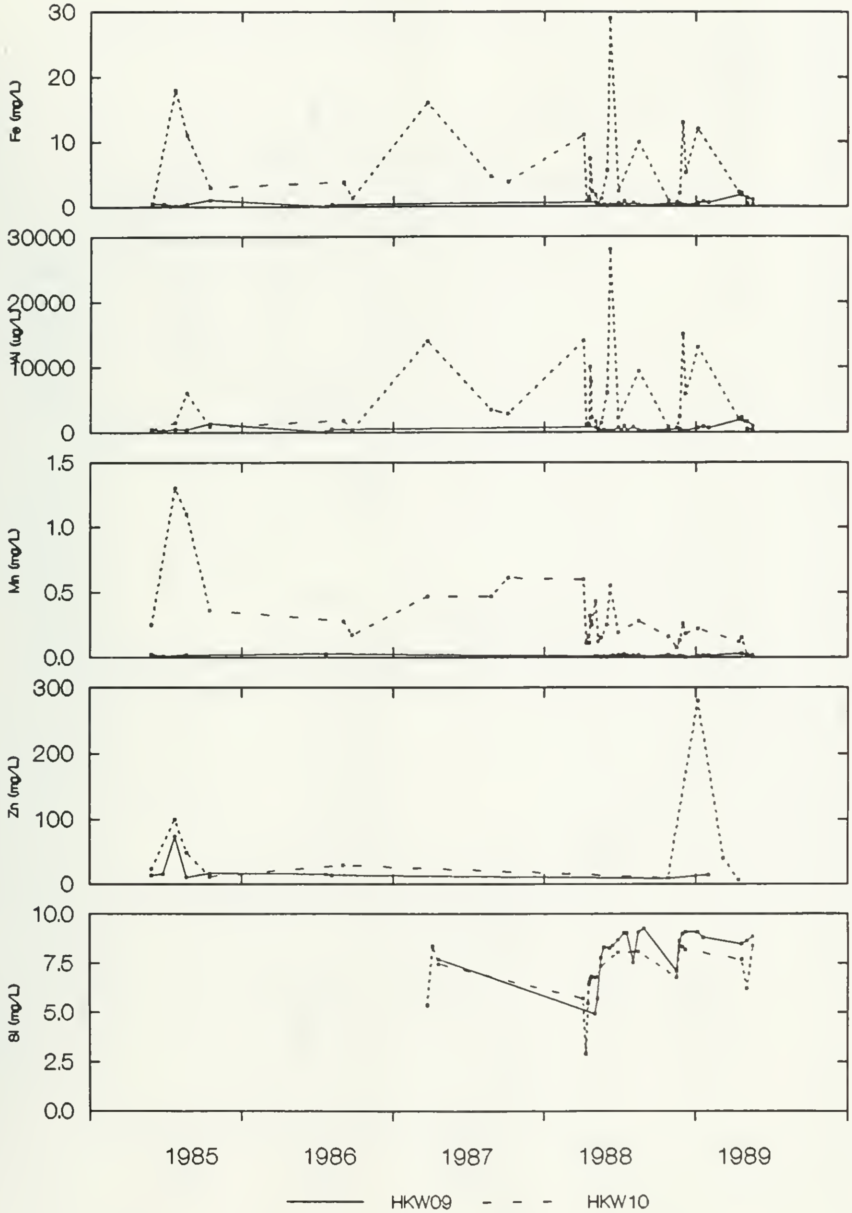


Figure 8d continued

HAWKEYE LAKE
STANDPIPES

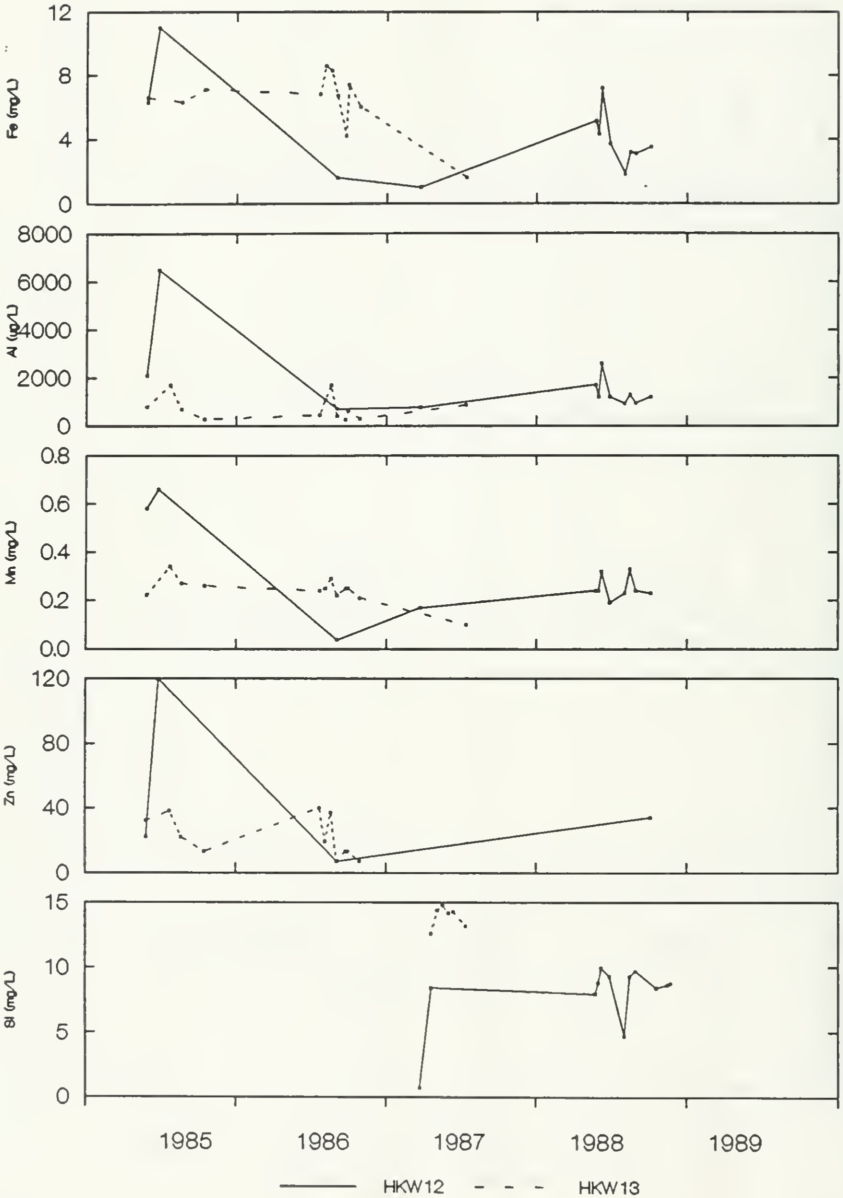


Figure 8d continued

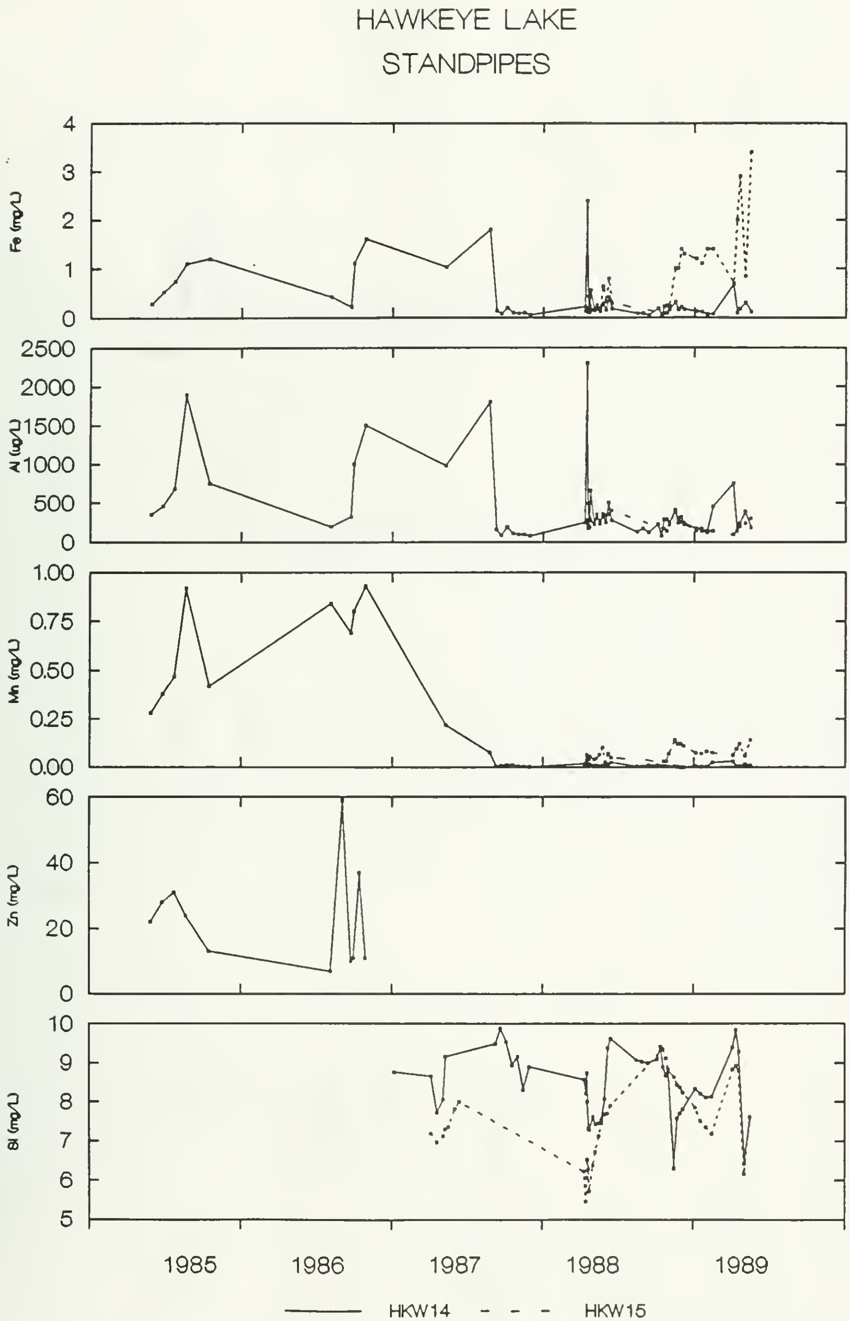


Figure 8d continued

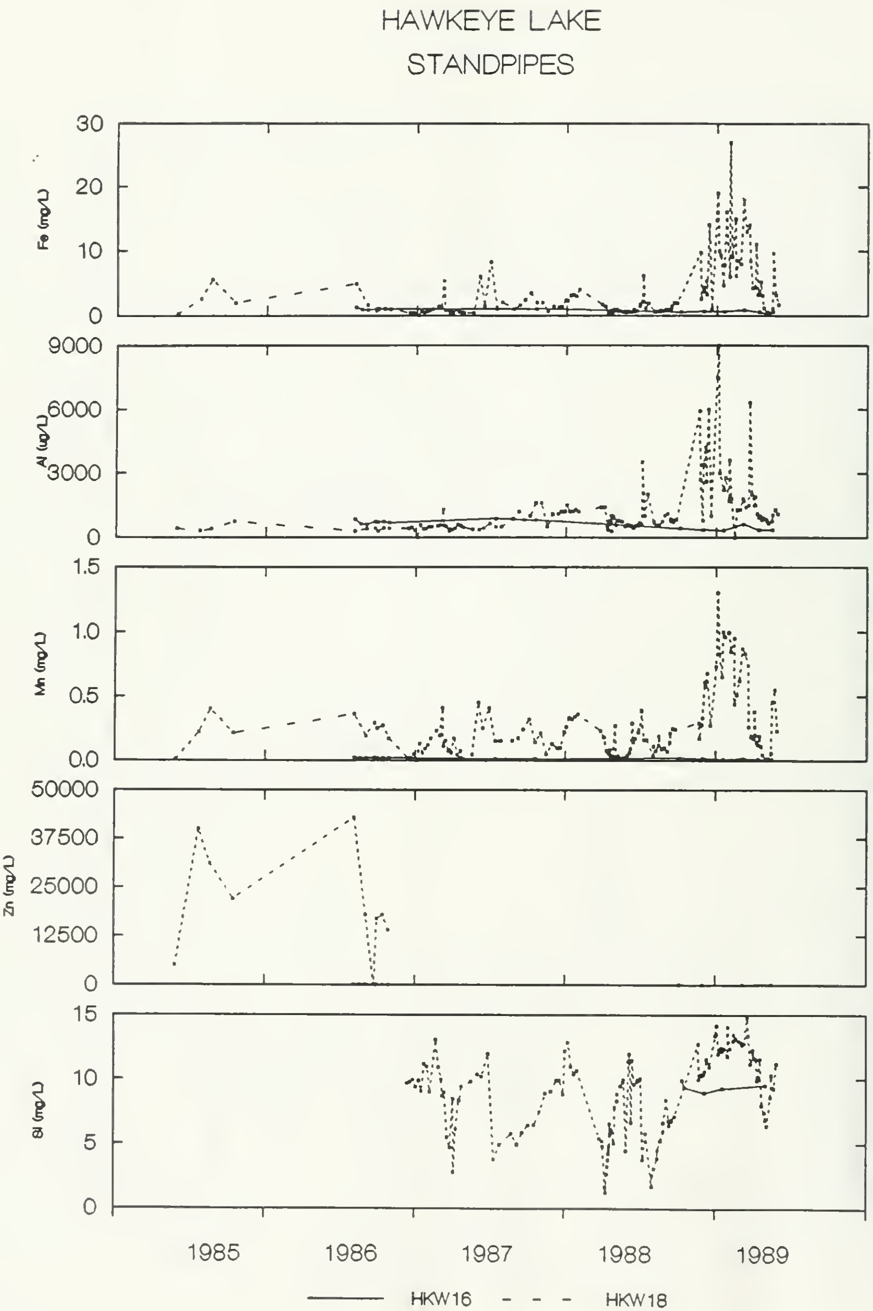


Figure 8d continued

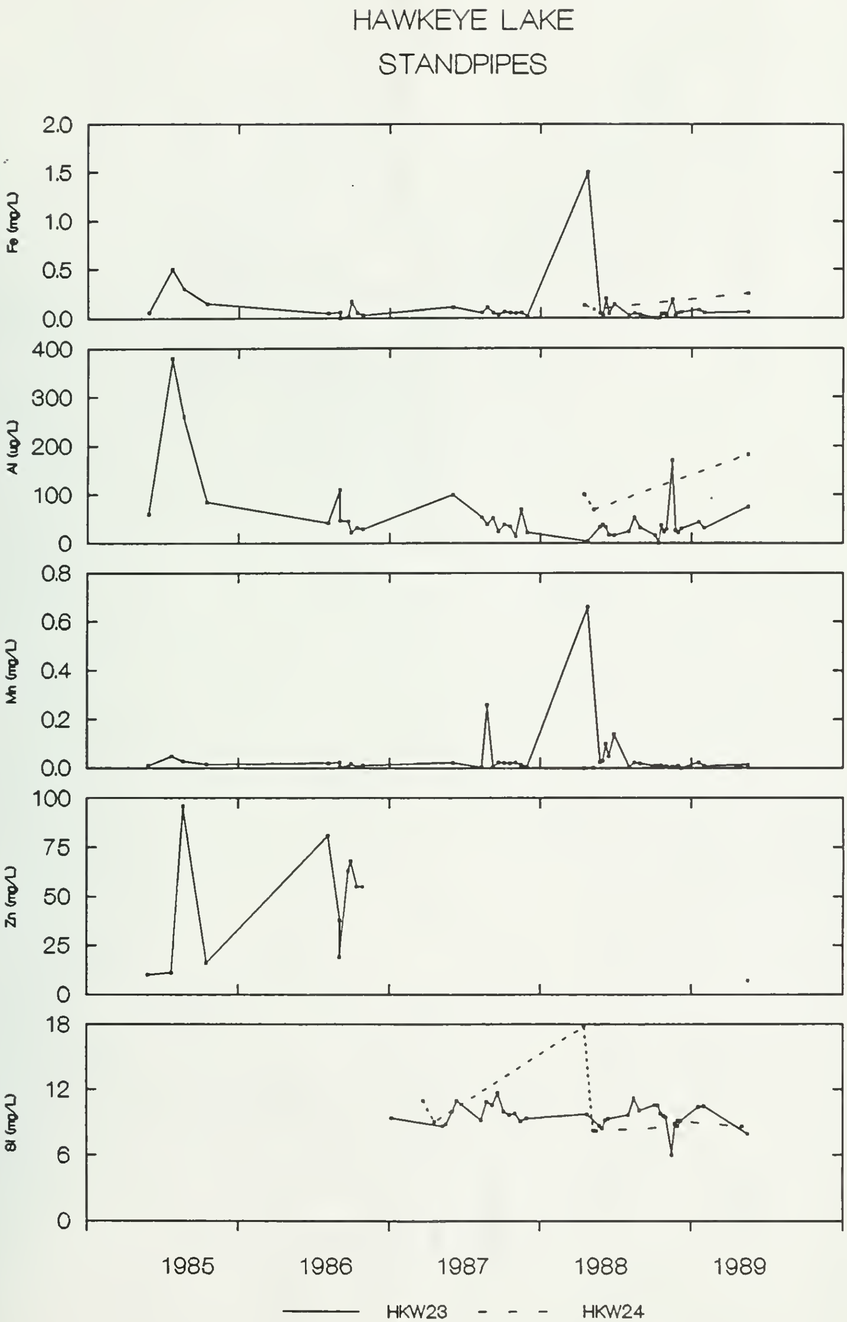
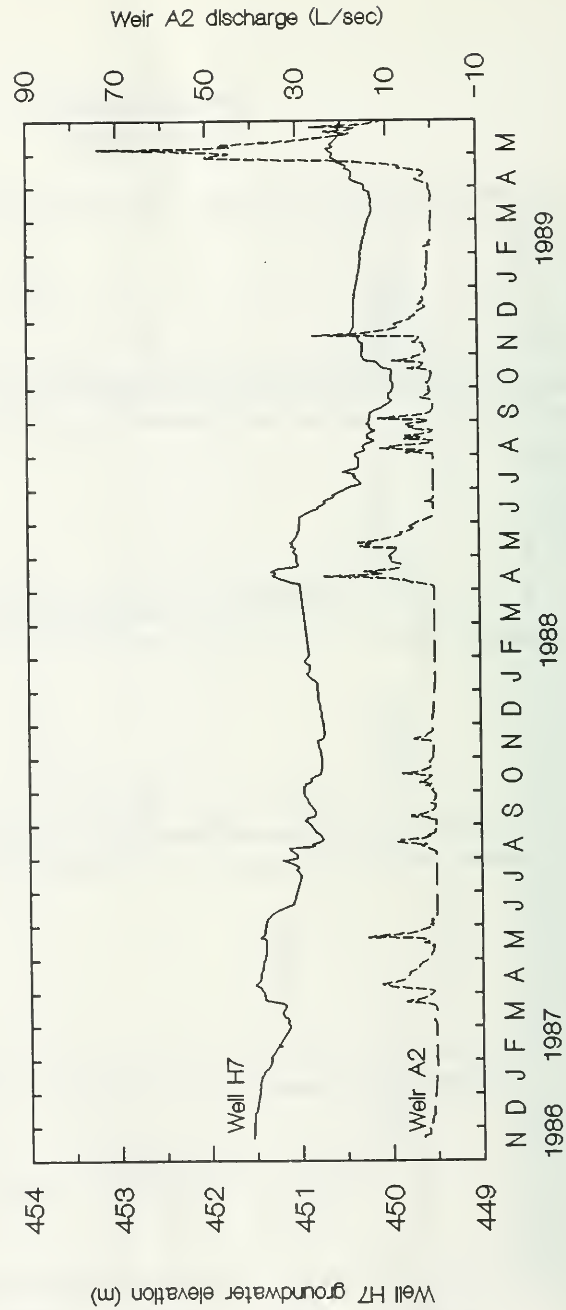


Figure 8d continued



Weir A2 discharge (L/sec)
90
70
50
30
10
-10
Well H7 groundwater elevation (m)
454
453
452
451
450
449
N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M
1986
1987
1988
1989
Well H7
Weir A2

Figure 9